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A COMPILATION OF SEDIMENT SURVEY REPORT SERIES ABSTRACTS 1984 TO 1989

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SEDIMENT SURVEY SECTION

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A COMPILATION OF SEDIMENT SURVEY REPORT SERIES ABSTRACTS TO 1989

Compiled

by

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PREFACE

This document presents a compilation of abstracts or summaries from eighty publications, Sediment Survey report series and manuals from the Water Resources Branch for the years 1984 to 1989. Included also are two unnumbered reports published in 1974 by R. Kellerhals, et al., and 1983 by T.R. Yuzyk.

Abstracts or summaries are copied directly from the reference reports and are organized in alphabetical order by Author.

PRÉFACE

Le présent document présente une compilation de résumés de quatre-vingt publications parues entre 1984 et 1989 dans la série des rapports et de manuels sur l'étude des sédiments de la Direction des ressources en eau. En font également partie deux rapports non numérotés publiés en 1974 par R. Kellerhals et coll. et en 1983 par T.R. Yuzyk.

Les résumés sont copiés directement du rapport cité et sont classés par numéro de série selon l'auteur.

ABSTRACT

Since 1984 the Sediment Survey Section of the Water Resources Branch, Environment Canada has published sediment related reports covering a wide range of topics in a "Sediment Survey Program Report Series". Some of the topics of these reports are: Sediment Issues, Studies, Workshops, Station Analysis, Equipment and Manuals. This document is a collection of the abstracts or introductions from these reports. Two earlier more popular sediment related reports from 1983 and 1974 were reprinted for circulation are included in this book. If an abstract was not available from the report the author included a brief summary of the report.

Copies of the reports referenced in this document are available upon request from:

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INTRODUCTION

This document represents a compilation of abstracts or the introductions from the Water Resources Branch, Environment Canada Sediment Survey report series published during 1984 to 1989.

In addition to the author(s) and title, an abstract or summary is provided. The latter is copied directly from the report or compiled by the author of this book.

The book is organized as follows:

1. An alphabetical list by author(s) showing the title of the report in the series and the page number location in this book.

2. The report abstracts or summaries are presented by author(s)

It is the intention of the Water Resources Branch to update this book as additional reports are written and published in the Sediment Survey report series.

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ABSTRACTS OR SUMMARIES OF REPORTS BY AUTHOR

ADAMOWSKI, K.

1984: Statistical Analysis of Sediment Data Records.

SUMMARY

The purpose of this report is to provide and discuss several statistical analyses of sediment data. Time series analysis, frequency analysis, and information content were investigated on three series of daily concentrations of different lengths.

The time series analysis of the monthly means revealed much periodicities in the sediment concentrations, especially for the two stations from Alberta where it accounted for seventy-seven and ninety-one percent of the variance of the series. Similarly, there were high periodicities in the daily data. There was no indication of trends in any of the three available series.

With daily sediment concentrations, their monthly means, as well as their annual means when possible, distributions were fitted to the three records. The usual distributions could not fit the daily data and the lognormal fitted the monthly means of the station from New Brunswick. The normal distribution fitted the annual means of that same record, while the lognormal will likely fit the other two, which are from Alberta. These two stations from Alberta were much more skewed than that from New Brunswick.

The variation of the information content throughout the year as well as the sample lengths required for a given degree of accuracy were determined. The monthly relative information content indicated that at the two stations from Alberta, because of the large seasonal variations in sediment concentrations, sampling could be reduced or even discontinued at certain times of the year, usually corresponding to winter months.

Because the annual means of these two highly skewed stations will likely be lognormally distributed, to which will correspond a high coefficient of variation, the required sample lengths for a ten percent accuracy in the mean with ninety-five percent confidence are enormous. Similarly, for the median, the sample lengths are also very large. At the New Brunswick station, however, only nine additional years of sampling are required to reach a ten percent accuracy in the mean with ninety-five percent confidence.

ASHMORE, P.E.
1987: Sediment Station Analysis: North Saskatchevan River at Prince Albert - 05GG001.

ABSTRACT

The Water Survey of Canada has operated a sediment station at Prince Albert (05GG001) since 1962. Until 1979 the data were collected year-round but since then the program has run between April and October only. Data are collected at a stable cross section in which the bed material is predominantly sand with gravel present on some small unstable bars.

Mean annual suspended sediment load is 3.09 x 10 t for the period 1963-1979 when annual flows were slightly above average. Annual flow and load declined through the late 1970s and early 1980s. Much of the annual load is transported during peak flows in April and July. The operation of Bighorn Dam since 1972 appears to have altered the flow and load regime such that April is now the dominant month instead of July. However, seasonal operation since 1978 has limited the amount of data available with which to assess this effect.

The existing particle size data are more than adequate to characterize the size distribution of the suspended sediment. The dominance of washload and possibly the homogeneity of the sediment sources result in the lack of an obvious trend in particle size with discharge. Point integrated sampling reveals the presence of some substantial variation in concentration across the channel, notably in the sand fraction.

While the existing data are generally adequate for regime characterization, it is recommended that an effort be made to better characterize the sediment regime since construction of the Bighorn Dam. In addition, establishment of seasonal stations in the basin upstream of Prince Albert may be necessary if major flow regulation projects are planned and also to provide background information on the major sources and fate of sediment in the basin.

RÉSUMÉ

La Division des relevés hydrologiques du Canada exploite depuis 1962 une station sédimentologique à Prince-Albert (05GG001). Jusqu'en 1979, les données étaient recueillies pendant toute l'année, mais depuis, elles ne le sont que d'avril à octobre seulement. La collecte de données se fait dans une section sable et de gravier présent sur quelques petits bancs instables.

De 1963 à 1979, alors que les débits annuels étaient légèrement supérieurs à la normale, la charge moyenne annuelle en sédiments en suspension était de 3,09 x 10t. La charge et le débit annuels ont diminué vers la fin des années 70 et au début des années 80. La plus grande partie de la masse annuelle des sédiments en suspension est

transportée pendant les débits de pointe d'avril et de juillet. Il semble que l'exploitation du barrage Bighorn depuis 1972 ait modifié le régime; maintenant, c'est avril, et non plus juillet, que est le mois dominant. Toutefois, l'exploitation saisonnière de la station depuis 1978 a réduit le nombre de donnée permettant de mesurer cet effet.

Les données déjà recueillies sur la dimension des particules sont plus que suffisantes pour établir la distribution granulométrique des sédiments en suspension. En raisonade la pr.domonance de la charge de ruissellement et peu-être de l'homogénéité des sources de sédiment, il n'existe pas de tendance évidente de la dimension des particules avec les débits. Les résultats de l'échantillonnage ponctuel par intégration indiquent d'importantes variations de la concentration d'un côté à l'autre du canal, notamment là où le lit est composé de sable.

Bien qu'en général les données actuelles soient suffisantes pour déterminer les caractéristiques du régime, il est recommandé de mieux définir celui des sédiments depuis que le barrage Bighorn a été construit. En outre, il serait peut-être nécessaire d'établir des stations saisonnières dans le bassin en amont de Prine-Albert si d'importants projets de régu[illegible]isation du débit sont prévus ainsi que pour fournir des données de bas[illegible]sur les principales sources de même que sur le devenir des sédiments dans le bassin.

ASHMORE, P.E.
1986: Suspended Sediment Transport in the Saskatchevan River Basin.

ABSTRACT

Compilation and analysis of suspended data from Water Survey of Canada sediment stations in the Saskatchevan River basin shovs that sediment yield are highest in the Alberta Plains portion of the basin and are particularly high along sections of the Oldman River and Red Deer River (greater than 100 t $km^{-2}a^{-1}$). The Mountain and Foothills basins generally have yields of between 10 and 40 t $km^{-2}a^{-1}$. This produces the unusual tendency for yield to increase, rather than decrease, downstream along the main rivers. The ratio of annual load to annual flov follovs a very similar pattern. Frequency distributions of daily yield and concentration shov that the large Prairie streams have higher median values than the Eastern Slopes basins but that the latter have more strongly skeved distributions and peak values quite close to those of the Prairie rivers. The basins with entirely Prairie runoff sources also have strongly skeved distributions of daily concentration and yield. Comparison of data between stations is complicated by differences in the period and length of the sediment record.

The greatest amount of information, from a total of 112 sediment stations is derived from 23 "seasonal/continuous" stations with over 4 years of record. By comparison the "miscellaneous" stations provide very little information apart from long-term load estimates whose accuracy is difficult to verify.

Monthly mean load follvs an annual pattern of variation very similar to that of discharge. Close to the Mountains there is a single peak in May or June, while in the large Prairie rivers two peaks often occur associated with spring runoff on the plains and later mountain snovmelt. Clockwise seasonal hysteresis in concentration is common, but some complications arise under regulation by upstream reservoirs.

The small Eastern Slopes basins tend to have larger proportions of their total load transported by extreme events larger than the mean annual flood and to have a great proportion of their annual load transported in fever days than the large Prairie basins. In most cases, the "effective" discharge for the Eastern Slopes basins has a lover frequency of exceedance than that of the Prairie basins.

There is a tendency for the average particle size of the suspended sediment load to decrease downstream along the main rivers as greater proportions of silt and clay are added to the load. However, large sediment traps, such as Lake Diefenbaker, nov interfere with this pattern. It is difficult to discern any systematic relationship between particle size and stream discharge, especially in the large Prairie rivers and the collection of data primarily during spring and early summer precludes analysis of trends through the year in particle size.

Review of data from other major drainage basins is recommended along with assessment of the miscellaneous data program and the particle-size analysis program. Future main-stem network changes should concentrate on the North Saskatchewan River. The impact of impoundment on the Cumberland Delta and on the Red Deer River downstream of Dickson Dam should be investigated. Future research should be aimed at sediment routing from the land through the stream network in basins of various drainage areas. This information can be used in tracing sediment-associated pollutants and in refining predictive models of suspended sediment yield.

ASHMORE, P.E., YUZYK, T.R., HERRINGTON, R.
1988: Bed-Material Sampling in Sand-Bed Streams.

ABSTRACT

A variety of bed-material samplers have been designed for sand-bed streams. There are several sources of error in the use of these samplers including systematic errors associated with the samplers themselves. Field testing of the Scoop, Canadian Drag Bucket, US BM-54 and US BMH-53 in the South Saskatchevan River at Saskatoon was carried out by collecting 50 replicate samples with each sampler from each of three verticals in a cross-section. The results show significant differences in particle size obtained using different samplers at a given vertical. These differences are particularly pronounced (up to 30% for D_{50}, and greater for the tails of the distribution) in silty sand where the Scoop and Canadian Drag Bucket fail to retain much of the fine sediment.

The statistical error in the replicate samples with a given sampler is quite variable between samplers and between verticals, but except in well-sorted, medium sand, multiple samples would be needed in almost all cases to determine D_{50} to within 10% with a probability of error of 0.1. The average sample mass collected by each of the samplers is easily sufficient to satisfy the ISO criterion for sample mass. Spatial variability in particle size along a 500 m reach of the river is as great as the sampling errors and between-sampler differences at a single vertical.

It is recommended that the US BM-54 (or 60) be adopted as the standard bed-material sampler for larger sand-bed streams and that further research be carried out to find the most suitable sampler for shallow (wadeable) sand-bed streams.

RÉSUMÉ

Divers échantillonneurs ont été conçus pour le prélèvement d'échantillons des matériaux du lit dans des cours d'eau à lit sablonneux. L'utilisation de ces échantillonneurs comporte un certain nombre d'erreurs incluant des erreurs systématiques reliées aux échantillonneurs. L'essai sur le terrain des échantillonneeurs Scoop, Canadian Drag Bucket, US BM-54 et US BMH-53, dans la rivière Saskatchevan Sud à Saskatoon, a consisté à recueillir 50 échantillons multiples par échantillonneur sur chacune des trois verticales dans une section transversale. Dans ces échantillons, on trouve des particules de dimensions différentes selon l'échantillonneur utilisé à une verticale donnée. Les dimensions de ces particules sont particulièrement élevées (jusqu'à 30 % pour D_{50}, et même plus pour les particules les plus grosses) dans le sable limonneux où les échantillonneurs Scoop et Canadian Drag Bucket retiennent mal les sédiments fins.

L'erreur statistique dans les échantillons multiples pour un échantillonneur donné varie d'un échantillonneur à l'autre et d'une verticale à l'autre, sauf dans le cas du sable à particules moyennes uniformes où l'on a presque toujours besoin de plusieurs échantillons pour calculer la valeur de D_{50} à 10 % près avec une erreur probable de 0.1. La masse moyennes de l'échantillon recueilli par chaque échantillonneur répond largement au critère de l'ISO en matière d'échantillon. La variation spatiale des dimensions des particules sur un tronçon de 500 m dans le cours d'eau est aussi grande que l'erreur d'échantillonnage, et varie d'un échantillonneur à l'autre à une verticale donnée.

On recommande d'utiliser le US BM-54 (ou 60) comme échantillonneur standard pour matériaux du lit dans les plus grands cours d'eau à lit sablonneux. On recommande aussi de poursuivre la recherche pour trouver le meilleur échantillonneur qui convient aux cours d'eau peu profonds (que l'on peut traverser à gué) à lit sablonneux.

BINDA, G.G.
1987: Ontario Sediment-Related Literature: Annotated Bibliography.

ABSTRACT

This report consists of a compilation of reference material pertaining to sediment in Ontario streams and lakes (excluding the Great Lakes).

It is divided into two sections: 1) references and abstracts and 2) a subject cross-reference index. Subjects cover a vide range of interests such as quality aspects of sediments (adsorbed contaminants and metals), erosional processes, sediment transport in rivers, sedimentation in reservoirs and lakes, and vater quality aspects. In addition the subject list contains the names of the rivers and lakes.

RÉSUMÉ

Ce rapport est un catalogue de références concernant les sédiments dans les rivières et lacs de l'Ontario (escluant les Grand Lacs).

Il est divisé en deux sections : 1) références et résumés et 2) un index de renvois par sujet. Les sujets englobent une large gamme d'intérêts tels la qualité des sédiments (contaminants et métaux adsorbés à la surface), les processus d'érosion, le transport de sédiments dans les rivières, la sédimentation dans les réservoirs et les lacs et la qualité des eaux. En plus, la liste de sujets contient les noms des rivières et lacs.

BINDA, G.G.
1987: Sediment Data Reference Index for Ontario.

ABSTRACT

This report consists of a reference index of available sediment data (fluvial and lacustrine, except for the Great Lakes) for Ontario. It is divided into a section on data collected by various public and private agencies and a second on data contained in published specific studies.

Both sections are separated alphabetically by major drainage basins within which the individual stations or rivers are also listed alphabetically.

Information available in the index are station name, number and location, collecting agency, sampling method, station purpose and the period of record for 1) suspended sediment (concentrations, loads and particle size), 2) bedload, 3) bed sediment particle size and 4) dissolved solids.

RÉSUMÉ

Ce rapport est un index de référence portant sur les données en sédiments (fluviaux et lacustres, à l'exception des Grands Lacs) disponible pour l'Ontario. La première section identifie les données recueillies par des agences publiques et privées. Une deuxième section identifie les données contenues dans les études spécifiques publiées.

A l'intérieur de chaque section, les données sont référées alphabétiquement selon les bassins versants principaux et leurs stations ou rivières.

Les informations fournies par cet index sont le nom, le numéro et la localisation de la station, l'agence des prélèvements, la méthode d'échantillonnage, l'objectif de la station et la période d'étude pour 1) les sédiments en suspension (concentrations, débits et granulométrie), 2) le charriage de fond, 3) la granulométrie des matériaux de lit et 4) les solides dissouts.

BINDA, G.G. and DAY, T.J.
1986: Sediment-Related Literature for the Western and Northern Region: Annotated Bibliography.

ABSTRACT

This report consists of a compilation of reference material pertaining to sediment in the Western and Northern Region of Inland Waters Directorate, Environment Canada.

It is divided into two sections: 1) references and abstracts and 2) a subject cross-reference index. Subjects cover a wide range of interests such as quality aspects of sediments, erosional processes, sedimentation in reservoirs, lakes and rivers and sediment transport in rivers.

RÉSUMÉ

Ce rapport est un catalogue de références concernant les sédiments dans la région de l'Ouest et du Nord, Direction des eaux intérieures, Environnement Canada.

Il est divisé en deux sections: 1) références et résumés et 2) un index de renvois par sujet. Les sujets englobent une large gamme d'intérêts tels la qualité des sédiments, les processus d'érosion, la sédimentation dans les réservoirs, les lacs et les rivières et le transport de sédiments dans les rivières.

BINDA, G.G.
1987: Sediment Station Analysis: Humber River at Elder Mills 02HC025.

ABSTRACT

Sediment data have been collected at the hydrometric gauging station, Humber River at Elder Mills 02HC025, from 1966 to 1986. Station objectives were two-fold; first, to complement biological studies on fish spawning habitats and second, to collect information for possible reservoir construction in the basin.

This report conveys hydrometric, suspended sediment, bed material and dissolved solids information in various tabular, graphical and statistical ways.

An increasing trend in flow has been observed since 1972 which probably reflects changing climatic conditions. This trend has also been noted in other streams in Southern Ontario.

The total suspended sediment load transported over the 1967-1985 period was 4.9×10^5 tonnes with a mean annual load of 25.8×10^3 tonnes. More than 75% of the annual load is carried during the January to May period. Annual loads show a distinct peak over the 1974 to 1980 period. An increase in the load contributed by June to December flows has been observed since 1975. The causes for these trends are unknown.

Suspended sediment particles size data indicate that the material being transported is composed on average of 21% clays, 59% silts and 20% sands. Dissolved solids concentrations show an inverse relationship with discharge. The annual solute load is approximately 23×10^3 tonnes. A combined annual load (suspended sediment and dissolved solids) of 45×10^3 tonnes has been estimated.

A continuation of the current sampling program is recommended until all the clients information needs have been assessed and that the hydrological and sediment trends present in the basin are understood more clearly.

RÉSUMÉ

Des données portant sur les sédiments ont été prélevées à l'emplacement de la station de jaugeage hydrométrique, Humber River at Elder Mills 02HC025, pendant la période 1966 à 1986.

Les objectifs de la station étaient premièrement de complementer des études biologiques portant sur les frayères et secondement de recueillir des données de base pour la construction possible d'un reservoir dans le bassin.

Les données hydrométriques, de sédiments en suspension, de matériaux du lit et de solides dissouts, sont exprimées de façons tabulaire, graphique et statistique.

Depuis 1972, une tendance vers des débits plus élevés a été observée résultant probablement de conditions climatiques plus favorables. Cette tendance a aussi été noté à d'autres bassins du sud ontarien.

La charge totale des sédiments en suspension transportée durant la période 1967-1985 fut de 4,9 x 10^5 tonnes. La charge moyenne annuelle est de 2,5 x 10^3 tonnes. Plus de 75% de la charge annuelle est transportée durant les mois de janvier à mai. Entre 1974 et 1980 une période de charge maximale a été observée. Une augmentation de la charge transportée par les débits des mois de juin à décembre a été noté depuis 1975. La cause de ces tendances demeure indéterminée.

Les données portant sur la dimension des particules de sédiments en suspension indiquent que le matériel transporté se compose en moyenne de 21% argile, 59% limon et 20% sables. La concentration de solides dissouts démontre une relation inverse avec le débit. La charge de solides dissouts se situe dans les environs de 23 x 10^3 tonnes. Une charge combinée annuelle (sédiments en suspension et solides dissouts) est estimée à 45 x 10^3 tonnes.

Il est recommandé que le programme de relevées actuel continu jusqu'à ce que les besoins des clients soient déterminés et que les tendances hydrologiques et de sédiments en suspension dans le bassin soient mieux comprises.

BINDA, G.G., DAY, T.J. and SYVITSKI, J.P.M.
1986: Terrestrial Sediment Transport into the Marine Environment of Canada: Annotated Bibliography and Data.

ABSTRACT

This report consists of a compilation of reference material pertaining to sediment transport into the marine environment of Canada. It is divided into three sections: 1) references and abstracts, 2) tables showing Water Survey of Canada data and data contained in specific studies and 3) a map showing the sites with available data.

RÉSUMÉ

Ce rapport est un catalogue de références concernant le transport de sédiments à l'environnement marin du Canada. Il est divisé en trois sections: 1) références et résumés, 2) tableaux illustrant les données compilées par la division des relevés hydrologiques du Canada et celles contenues dans des études particulières et 3) une carte indiquant la localisation des sites étudiés.

BLACHFORD, D.P. and DAY, T.J.
1986: Sediments in Water Quality Assessments: Opportunities for Integrating Water Quality and Water Resources Branches Activities.

EXECUTIVE SUMMARY

Inland Waters/Lands has opportunities for integration of operational activities in addressing the issue of the role of fluvial sediments in environmental quality. These sediments, particular their fine proportions, play a dominant role in the quality of the aquatic environment as they are capable of transporting quantitites of nutrients and contaminants to and within aquatic systems, and of regulating nutrients and contaminant availability to the biological community.

Determining the status of aquatic quality is the primary responsibility of Water Quality Branch. Water quality assessments conducted by the Branch provide data and information regarding aquatic quality. The goals of the assessments are to establish for envionmental impact assessments and to monitor for the development of or compliance with water quality objectives. The Sediment Survey Program of Water Resources Branch provides data on particle size and sediment concentration as well as information on seasonal and spatial variability of suspended sediment in fluvial and lacustrine systems. The goals of the assessment can only be met with the availability of this type of physical sediment data.

The roles of Water Quality and Water Resources Branches can be linked with regards to the procurement and usage of sediment data as part of water quality assessments. Water Resources Branch through its Sediment Survey activities provides expert advice on sediment dynamics, environmental processes and interpretation. A unique and important opportunity exists to address sediment issues be they toxic-related or simply a physical characteristic capable of limiting bioproductivity.

This report identifies opportunities for a new and improved working relationship between the Branches.

CARSON, M.A.

1987: An Assessment of Problems Relating to the Source, Transfer and Fate of Sediment along the Mackenzie River, NWT.

EXECUTIVE SUMMARY

This report describes, in some detail, the major issues related to sediment transport along the Mackenzie River downstream of Great Slave Lake. It is organized in three parts.

Part One provides a background to the study, describes the general character of the Mackenzie river, and summarizes the eleven sediment-related issues identified. Part Two deals with each of these eleven concerns, individually, according to the following format: the issue itself; information needs for addressing the issue; adequacy of existing information available; and recommendations for further work necessary to remedy deficiencies in current knowledge. Part Three provides a summary of the recommendations (with some indication of their priorities) and a list of publications consulted in the work.

Eleven major issues are identified. The first five deal with sediment transported in suspension by the Mackenzie; the last six concern sediment found on the river bed. There is some degree of linkage between the two groups of problems, because some of the material on the river bed actually moves in suspension at high flows. Most of the suspended load, however, is not derived from the river bed. The eleven issues are:

1. the magnitude, timing and spatial pattern of influx of suspended sediment from the river to the Beaufort Sea: these are key factors controlling the offshore sediment plume (and its relationship to marine productivity), rates of infill of pipeline trenches, seabed stability etc.;

2. inputs of suspended sediment to the Mackenzie Delta as this affects the rate of build-up of the Delta surface - a crucial issue in view of fears of future submergence of the Delta with increasingly rapid rates of local sea level rise and possible permafrost degradation due to global warming;

3. the magnitude, timing and spatial pattern of nutrient supply to the Delta and the Beaufort Sea, bearing in mind that much of the nutrient load is bound to the fine-grained suspended load of the river;

4. the transport of contaminants (hydrocarbons, heavy metals etc.) to the Delta and the Beaufort Sea, many of which are also moved primarily in association with the fine-grained fraction of the suspended load;

5. identification of the main tributary sources of the suspended load of the Mackenzie, so that the impact of land use changes in these tributaries (e.g. damming of the Liard for hydro power) on the inputs of sediment, nutrients and contaminants at the mouth of the Mackenzie can be assessed in advance of the changes;

6. transport rates of bed material along the channel floor of the Mackenzie, partly to enable calculation of inputs to the Delta (and hence allow assessments of the stability of Delta channels in the years ahead), but more generally to provide a scientific basis for answering more specific issues considered next (7-11) that hinge on the rate of transport of bed material in the channel;

7. shoaling of sediment in key reaches of the Mackenzie bed, as it affects navigation and the need for channel dredging-especially in relation to the increased traffic in the years ahead associated with oil and gas development;

8. the need to acquire a better understanding of the processes of scour and fill of the bed and banks, under ice and breakup conditions, especially in relation to the stability of pipeline crossings of the mainstem;

9. the need to acquire a better understanding of the role of shoals of sandy bed sediment in localizing ice jams during spring breakup, with the goal of eliminating, reducing or at least predicting, flooding associated with such ice jams;

10. the rapid expansion of the artifical islands at Norman Wells by trapping of sediment, and the implications of this for navigation and ice jams in the local area;

11. the environmental consequences of possible extraction of large quantities of granular material from the bed of the Mackenzie, particularly in connection with pipeline construction along the valley axis.

Recommendations are made for future work needed to supplement existing data in order to address the issues raised above. The major recommendations may be summarized as follows:

(a) an immediate, in-depth, review of the data for the five main sediment stations on the lower Mackenzie system, to establish whether or not sufficient data exist to develop numerical models for the prediction of suspended sediment loads (broken down by particle size and timing) at these sites from routinely collected hydraulic data such as discharge, water temperature etc.; this will enable decisions to be taken as to whether routine sampling can be terminated at these stations, allowing redeployment of resources elsewhere;

(b) a similar analysis of annual loads of bed material sediment in key reaches of the river by analysis of bathymetric charts in areas where repeat surveys have been undertaken by the Canadian Hydrographic Service;

(c) following (b), resurveys of key reaches of the river to allow updating of data to the 1980's, and to rectify gaps in the data file;

(d) following (a), addition of new sediment stations to the Mackenzie network allowing routine monitoring of suspended material in key reaches: Wrigley, Norman Wells and Fort Good Hope, and at the mouths of the three main Delta channels;

(e) following (d), once the sediment regime at these new stations has been established, expansion of the programme at these sites to include nutrients, hydrocarbons and heavy metals;

(f) an increase in basic research into ice-jamming in relation to shoaling and into the effects of an ice cover on bed scour.

Above all, an agency should be established to ensure full coordination of sediment and water-related issues in the Mackenzie basin downstream of Great Slave Lake. At the present time, it is apparent that many agencies are pursuing investigations into water and sediment in the Mackenzie corridor without appreciating that their work is related, often intimately, to other studies by other agencies. In addition, much of the data collection is not standardized among different agencies, with different techniques of sampling, storage and analysis; as a consequence, results are often difficult to compare.

It is also readily apparent that, while acquisition of sediment data in the North is expensive, and while it often cannot be justified on the basis of a single agency's concerns, sediment issues in the Mackenzie touch so many different departments that failure to acquire the data cannot be justified either. The obvious solution is greater cooperation among departments, and some form of inter-departmental (including private enterprise) cost-sharing.

CARSON, M.A.
1987: Mackenzie River, NWT: Sediment-Related Issues and Recommendations.

EXECUTIVE SUMMARY

This planning document describes, in some detail, the major issues related to sediment transport along the Mackenzie River downstream of Great Slave Lake. Eleven major issues are identified. These are:

1. the magnitude, timing and spatial pattern of influx of suspended sediment from the river to the Beaufort Sea: these are key factors controlling the offshore sediment plume (and its relationship to marine productivity), rates of infill of pipeline trenches, seabed stability etc.;

2. inputs of suspended sediment to the Mackenzie Delta as this affects the rate of build-up of the Delta surface - a crucial issue in view of fears of future submergence of the Delta with increasingly rapid rates of local sea level rise and possible permafrost degradation due to global warming;

3. the magnitude, timing and spatial pattern of nutrient supply to the Delta and the Beaufort Sea, bearing in mind that much of the nutrient load is bound to the fine grained suspended load of the river;

4. the transport of contaminants (hydrocarbons, heavy metals etc.) to the Delta and the Beaufort Sea, many of which are also moved primarily in association with the fine grained fraction of the suspended load;

5. identification of the main tributary sources of the suspended load of the Mackenzie, so that the impact of land use changes in these tributaries (e.g. damming of the Liard for hydropower) on the inputs of sediment, nutrients and contaminants at the mouth of the Mackenzie can be assessed in advance of the changes;

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7. shoaling of sediment in key reaches of the Mackenzie bed, as it affects navigation, and the need for channel dredging especially in relation to the increased traffic in the years ahead associated with oil and gas development;

8. the need to acquire a better understanding of the processes of scour and fill of the bed and banks, under ice and breakup conditions, especially in relation to the stability of pipeline crossings of the mainstem;

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f. an increase in basic research into ice-jamming in relation to shoaling and into the effects of an ice cover on bed scour.

Above all, an agency should be established to ensure full coordination of sediment and water-related issues in the Mackenzie basin downstream of Great Slave Lake.

CARSON, M.A.

1989: Sediment Observations on the Mackenzie River Network: Summary and Recommendations for Future Work.

PREAMBLE

This report presents a summary of three previous reports that were concerned with the evaluation of sediment data at the five main sediment sampling stations of the Water Survey of Canada in the lower Mackenzie basin, Northwest Territories: the Mackenzie River upstream of Arctic Red River (Carson, 1988b); the Liard River and the Mackenzie River upstream of the Liard River (Carson, 1988c); the Arctic Red near its mouth and the Peel River above Fort McPherson (Carson, 1989).

These reports are proprietary reports and not intended as summary documents for agencies interested in using the sediment data of the lower Mackenzie network. An appropriate user-document cannot be prepared until additional remedial sampling is done at these sites, and until discharge data, especially on the Peel and lower Mackenzie River, have been revised.

The assistance of numerous personnel attached to the Inland Waters Directorate in the preparation of these reports is acknovledged. Special thanks are due to Terry Day, Morley Cashman, and Joseph McIlhinney in Ottawa; Jack Wedel, Henry Westermann and Chris Heron in Yellovknife; Herb Wood and his staff in Inuvik; Pat Wood in Fort Simpson; and Richard Yungwirth in Regina.

PRÉAMBULE

Le présent rapport fournit un sommaire de trois rapports déjà parus au sujet de l'évaluation des données sur les sédiments aux cinq principales stations d'échantillonnage des sédiments que possède la Division des relevés hydrologiques du Canada dans le bassin inférieur du Mackenzie, dans les Territoires du Nord-Ouest. Il s'agit plus précisément des stations suivantes : fleuve Mackenzie en amont de la rivière Arctic Red (Carson, 1988b); rivière Liard et fleuve Mackenzie en amont de la rivière Liard (Carson, 1988c); rivière Arctic Red près de son embouchure et rivière Peel en aval de Fort McPherson (Carson, 1989).

Ces rapports sont la propriété de la Division et ne visent pas à servir de sommaires pour les organismes intéressés à utiliser les données sur les sédiments pour le réseau du bassin inférieur du Mackenzie. Il faudra effectuer d'autres échantillonnages correcteurs à ces stations et réviser les données sur le débit, notamment pour la rivière Peel et le bassin inférieur du Mackenzie avant d'être en mesure de produire un document approprié à l'intention des utilisateurs.

Nous remercions les nombreuses personnes de la Direction générale des eaux intérieures qui ont collaboré à la préparation de ces rapports et notamment Terry Day, Morley Cashman et Joseph McIlhinney d'Ottawa; Jack Wedel, Henry Westermann et Chris Heron de Yellovknife; Herb Wood et son personnel à Inuvik; Pat Wood de Fort Simpson; et Richard Yungwirth de Regina.

CASHMAN, M.A.
1988: Digitizing Procedures for Suspended Sediment Data.

PREFACE

The Water Resources Branch of the Department of Environment is responsible for the national program of collecting, analyzing and disseminating water quantity data and to provide information and advice, concerning this aspect of Canada's inland waters. Water quantity or hydrometric data consists mainly of water levels, flows and sediment transport.

Sediment Survey Field and Office Manuals are prepared to define and describe standard procedures and practices to be followed by Water Resources Branch personnel in the collection, processing, computing and publication of Sediment Survey data.

Sediment Survey Manuals are also used as basic training aids by Water Survey of Canada technicians who are progressing through their career development program. Standards defined within the manuals reflect the optimum procedures and practices in their time and therefore, cannot be considered static. Suggestions to effect change will be welcome and will be given careful consideration.

This manual of Digitizing Procedures for Suspended Sediment Data was prepared by the Sediment Survey Section of the Water Survey of Canada Division in Hull. Contributions in the form of suggestions and revisions were received from region offices of the Water Resources Branch and are gratefully acknowledged.

While this manual and selected other manuals released by the Water Resources Branch are intended for internal use, they are available on request to any other agencies or to individuals.

CASHMAN, M.A
1988: Office Procedures for Sediment Data Computations.

PRÉFACE

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While this manual and selected other manuals released by the Water Resources Branch are intended for internal use, they are available on request to any other agencies or to individuals.

CASHMAN, M.A.
1988: Sediment Survey Equipment Catalogue.

INTRODUCTION

This catalogue was prepared to assit those involved in ordering sampling equipment for sediment investigations. This publication illustrates current instruments and supplies. Obsolete equipment has been omitted.

Equipment orders should be forwarded on a purchase order to the National Equipment Distribution Centre. Telephone inquiries are invited; but because most equipment items are property-controlled, equipment cannot be shipped before receipt of purchase order.

Because the National Equipment Distribution Centre has no budget it therefore operates on a non profit cost recovery basis. Equipment costs are based on the latest available price list from the "Federal Inter-Agency Sedimentation Project" St. Anthony Falls Laboratory. Costs for individual items are maintained at a minimum, consequently no discount is offered for quantity purchases.

All measurements and weights in this catalogue are given in metric units. The scale shown in most photographs is graduated every 1 cm and is 20 cm in length. For convenience purposes the following equivalents of the more common sampler weights and nozzle sizes are listed below.

Samplers		Nozzles	
US DH-48	3.5 lb. - 1.6 kg	Small	1/8 in. - 3.18 mm
US D-59	22 lb. - 10.0 kg	Medium	3/16 in. - 4.76 mm
US D-74	62 lb. - 28.1 kg	Large	1/4 in. - 6.35 mm
US P-61	105 lb. - 47.6 kg		

Because of the wide range of sampling conditions encountered and the variety of installations at measurement sites, a number of different depth-integrating and point-integrating samplers have been designed. Samplers suspended by cable are suitable for operating from bridges, cableways, and boats.

Reports pertaining to development and theory of equipment operation, and to sampling and computational methods are listed in the back of this catalogue. Questions regarding theory and operation should be addressed to the Head, Sediment Survey Section, WRB, Environment Canada, K1A 0H3, (819-953-1560).

CASHMAN, M.A.

1987: Repeatability and Sensitivity Study of Suspended Sediment Data Computation.

ABSTRACT

This project was initiated to determine the repeatability of suspended sediment loads produced by standard Water Survey of Canada methods. The sensitivity of loading values were also examined. The study was conducted using the suspended sediment concentration data and the original records for 1969 for the sediment sampling station Assiniboine River at Headingley (05MJ001).

The awareness of uncertainties in sample collection techniques, computation, and their affect on the sediment loads, as well as concern for the increasing cost of collecting and analyzing suspended sediment samples have led to the review of sampling strategies. This included a review of the number of cross-section measurements taken, and the increased reliance on data obtained from single vertical sampling. The number of measurements and single vertical samples were reduced for each test.

The analysis indicates that the sample coverage can be reduced considerably. The usual high volume of sampling must be maintained during the freshet while sampling during the winter months can be deleted. The reduced sample collection resulted in a repeatability of the annual loads to within 5% while showing a reduction in laboratory costs of approximately 80%. This study also shows that large errors may affect individual days or short periods due to sampling strategies, but when comparing the total annual loads the differences are insignificant. Furthermore the results indicate that the use of the K factor is not warranted if total annual loads are the only interest.

RÉSUMÉ

Ce projet avait pour but de déterminer s'il est possible de reproduire les résultats obtenus sur le transport des matières en suspension grâce aux méthodes utilisées couramment à la Division des relevés hydrologiques du Canada. On a également examiné la sensibilité des valeurs sur le transport solide. L'étude portait sur les données relatives à la concentration des matières en suspension et sur les observations enregistrées en 1969 à la station d'échantillonnage des sédiments de la rivière Assiniboine à la hauteur de Headingley (station 05MJ001).

Etant donné les doutes émis au sujet des techniques de collecte de données et de calcul ainsi que de leurs effets sur les données portant sur le transport solide et compte tenu des inquiétudes entourant le coût croissant de la collecte et de l'analyse des échantillons de matières en suspension, on a passé en revue les stratégies d'échantillonnage.

On a donc examiné le nombre de mesures effectuées sur des coupes transversales et la fiabilité accrue des données obtenues au moyen d'un échantillonnage sur une seule verticale. On a ensuite réduit, pour chaque test, le nombre de mesures et d'échantillons prélevés sur une verticale unique.

Selon l'analyse, le nombre d'échantillons peut être réduit considérablement. On doit maintenir le volume habituellement élevé d'échantillonnages durant la montée des eaux, tandis qu'on peut supprimer tout échantillonnage en hiver. En réduisant le nombre de prélèvements, on a reproduit à près de 5% les données sur le transport annuel et calculé une baisse d'environ 80% des coûts de laboratoire. L'étude démontre aussi que l'utilisation des stratégies d'échantillonnage peut entraîner des erreurs importantes certains jours ou pendant de courtes périodes; ces écarts sont toutefois négligeables lorsqu'on les compare aux données concernant le transport annuel total. L'étude précise enfin que l'utilisation du facteur K est injustifiée si on s'intéresse uniquement au transport annuel total.

CASHMAN, M.A.
1987: Laboratory Procedures for Sediment Analysis.

PREFACE

The Water Resources Branch of the Department of Environment is responsible for the national program of collecting, analyzing and disseminating water quantity data and for providing information and advice concerning this aspect of Canada's inland waters. Water quantity or hydrometric data consist mainly of water levels, flows and sediment transport.

Field and Office Manuals are prepared to define and describe standard procedures and practices to be followed by the personnel in the collection, processing, computing and publication of surface water data.

Sediment Manuals are used as basic training aids by Water Survey of Canada technicians who are progressing through their career development program. Standards defined within the manuals reflect the optimum procedures and practices in their time and therefore, cannot be considered static.

PRÉFACE

La Direction des ressources en eau du ministère de l'Environnement est responsable du programme national de collecte, d'analyse et de diffusion des données sur la quantité des eaux. Elle est également chargée de fournir renseignements et conseils ayant trait à la quantité des eaux intérieures canadiennes. Les données sur la quantité des eaux, ou données hydrométriques, concernent principalement le niveau d'eau, le débit et le transport des sédiments.

Les manuels pratiques et les manuels théoriques servent à définir et à décrire les méthodes et pratiques courantes que doit suivre le personnel de la Direction pour la collecte, le traitement, le calcul et la publication des données sur les eaux de surface.

Quant aux manuels sur les sédiments, ils servent de matériel pédagogique de base aux techniciens de la Division des relevés hydrologiques du Canada qui progressent dans le cadre du Programme de formation professionnelle. Les normes définies dans les manuels traduisent les meilleures méthodes et pratiques disponibles au moment de leur publication et peuvent donc être appelées à changer.

CASHMAN, M.A. and SPITZER, M.O.
1986: Sediment Station Analysis: South Saskatchewan River at Highway No. 41.

ABSTRACT

Water Survey of Canada has collected sediment data at the South Saskatchewan River at Highway No. 41 (05AK001) since April 1966. This sediment station was established primarily to quantify the sediment input to Lake Diefenbaker. The report was prepared to evaluate whether the sediment program has met this objective and if so whether sufficient sediment data are now available to adequately document the sediment transport characteristics at this site.

Until 1978 the data were collected year-round but since then the station has only been operated seasonally, April to October. Suspended sediment data are collected at a generally stable cross section in which the bed material is predominantly sand with some gravel present.

Most of the annual load is transported during the peak flows in June. The mean annual suspended sediment load was 3.2×10^6 for the 12-year period 1967 to 1978, a period when annual flows were above average.

Existing particle size data are sufficient to characterize the particle-size distribution of the suspended sediment. The particle size distribution is dominated by silts and clays. Sediment samples collected by the point-integrated method reveal that the concentration is consistent both vertically and laterally across the channel. Sand particles are distributed proportionately throughout each sampling panel.

Results of this station review indicate that further intensive sample collection will not improve our general knowledge of the sediment transport at this site. It is, therefore, recommended that the detailed sampling program be replaced by a miscellaneous program focusing on the range of discharges that have not yet been sampled.

A by-product of this study is the compilation of all available sediment data into one package and the presentation of various pertinent sediment data features in tabular and graphical formats. Thus the report will be a useful tool for engineers, geomorphologists and environmentalists working on projects on the South Saskatchewan River.

RÉSUMÉ

Les Relevés hydrologiques du Canada recueillent depuis 1966 des données sur les sédiments à la station de jaugeage 05AK001 située sur la rivière Saskatchewan Sud à la hauteur de l'autoroute 41. Cette station a été établie principalement pour quantifier l'apport de sédiments au lac Diefenbaker. Le présent rapport a été rédigé afin d'évaluer si le programme d'étude des sediments avait permis d'atteindre cet objectif et, dans l'affirmative, s'il existe suffisamment de donner sur les sédiments

pour documenter adéquatement les caractéristiques du transport des sédiments à cette station.

Jusqu'en 1978, les données étaient recueillies durant toute l'année; toutefois, la station est exploitée de façon saisonnière depuis, soit d'avril à octobre. Les données sur les sédiments en suspension sont recueillies à la section transversale généralement stable où les matériaux du lit qui s'y déposent sont principalement composés de sable parsemé d'un peu de gravier.

La plupart du transport annuel des sédiments s'effectue en juin au moment où l'on enregistre des débits de pointe. Le débit annuel moyen des sédiments en suspension est de $3,2 \times 10^6$ pour les 12 ans entre 1967 et 1978, alors que les débits annuels étaient supérieurs à la moyenne.

On dispose présentement de plus de données sur la granulométrie qu'il n'en faut pour caractériser la granulométrie des particules en suspension, laquelle est dominée par la charge de ruissellement. L'analyse des échantillons de sédiments prélevés par la méthode ponctuelle révèle que la concentration est uniforme tant verticalement que latéralement dans le canal. Les particules de sable sont réparties proportionnellement à la grandeur de chacune des sous-sections ou s'effectue l'échantillonnage.

Les résultats obtenus par la revue de cette station indiquent que des collectes supplémentaires et intensives d'échantillons n'amélioreront pas la connaissance globale du transport des sédiments à cet endroit. Il est donc recommandé de remplacer le programme d'échantillonnage détaillé par un programme diversifié s'attardant à la gamme de débits qui n'ont pas encore fait l'objet d'échantillonnage.

Un des produits secondaires de cette étude est la compilation en répertoire de toutes les données disponibles sur les sédiments et la présentation de diverses caractéristiques des données pertinentes sur les sédiments sous forme de tableaux et de graphiques. Le rapport sera donc utile aux ingénieurs, géomorphologues et écologistes qui exécutent des projets sur la rivière Saskatchewan Sud.

CHURCH, M., MILES, M. and ROOD, K.
1986: Sediment Transport along Mackenzie River: A Feasibility Study.

INTRODUCTION

Although it is one of the major rivers of North America, the remoteness of Mackenzie River has discouraged study of it. Hence, channel hydraulics and sediment transport remain poorly known. Proposed resource developments along the river and the desirability to develop a regional water management plan now require that knowledge of these phenomena be improved more rapidly than could be achieved by the expansion of conventional monitoring programs alone.

Information on sediment transport characteristics can be obtained from non-traditional sources. Specifically, historic planimetric and topographic surveys, aerial photographs and hydrographic sounding, supplemented with limited observations of sediment transport, might be used to construct an approximate sediment budget on a reach-by-reach basis.

In the long term, understanding the viability of alluvial ecosystems requires that the character of erosion and sedimentation be understood on a reach basis. It is appropriate to draw evidence from morphological and sedimentary studies, rather than just from sediment transport monitoring, because information of the appropriate character and resolution can be gained in that way. Net change within reaches - rather than total throughput of sediment - is critical for river stability. Further, it requires many years' monitoring, conducted at great expense, to establish the trend of river stability. Where map, chart, or air photo evidence is available, trends can be established from the observed pattern of changing morphology.

Some monitoring remains important in order to permit more detailed interpretation of net morphological changes in terms of a sediment budget.

The present project resulted from a request by Dr. T.J. Day, Head, Sediment Survey of Canada, to Professor Michael Church, at the University of British Columbia, to consider whether map and photo records could be used to obtain useful information on Mackenzie River. Because there is relatively little information available on the river, it is prudent first to undertake a feasibility study of the approach.

CHURCH, M., McLEAN, D.G., MANNERSTROM, M.C. and EVANS, D.
1984: Reference Materials on Sedimentation and Morphology of the Lower Fraser River.

INTRODUCTION

This report presents a compilation of reference materials on the subjects of physical hydrology, sedimentation, morphology, and related engineering problems on the lower course of Fraser River, British Columbia. The "lower course" of the river is taken to mean the river between Yale and the sea, a distance of some 190 km (114 miles). This includes the entire length of the alluvial channel of the river below Fraser Canyon (cf. figure 1).

Between Yale and Hope (165 km; 99 mi. above the mouth), the river flows in a straight, single channel that is more or less constricted between Pleistocene terraces and, sometimes, bedrock. Below Hope, the river flows through its own floodplain and delta to the sea. Between Wahleach Creek (Laidlaw) and the mouth of Sumas River the channel is braided, and below that follows a single channel to the head of its "modern delta" at Port Mann, near the city of New Westminster. The lowermost 98 km (59 mi.) of the river's course may be subject to tidal influences during at least part of the year but, during the annual spring freshet tidal influence is much more restricted. Salt water is restricted to the lowermost few kilometres of the Douglas Island and corresponds to that part of the river that is substantially affected by tides.

There are several major channels connecting the river with major lakes on the north side of the floodplain, and several more or less insignificant tributaries flowing to the main river on the south side. These channels and their alluvial deposits are included within the purview of the bibliography, though there is relatively little published work to report.

In making decisions about what material to include, criteria were adopted:

1. The report attempts to be exhaustive in the central areas of clastic sedimentation and alluvial morphology. In relevant areas, such as physical hydrology and hydraulics, surficial geology, engineering and hydrological material was excluded--particularly relatively obscure reports that only incidentally contain information that is more explicitly or more readily available elsewhere. The particular subject of transport of dissolved materials has been included by listing major reports and sources of data. The general subjects of water quality and pollution of lower Fraser River waters have not been included, though.

2. The report is restricted to material making specific reference to Fraser River. General reference works are excluded.

3. The report is restricted to material that is publicly accessible. A great deal of valuable information has been gathered in the course of commissioned engineering investigations. In many cases, however, the results remain restricted either by confidentiality or by the simple fact that the reports remain in one or two copies in private hands. Such reports are not listed. Engineering and planning reports prepared for government agencies commonly become accessible for general or specific purposes and these are listed. The appearance of a reference in this report should not, however, be construed to mean that it is casually available.

4. The report does not list projects in progress.

5. References have generally been examined and confirmed by the writers, except as explicitly noted. In cases where the material has not been seen, it is included only if it has been reliably referenced in more than one source.

The bibliography is assuredly not complete. In several places, the existence of unexamined data resources is noted. Beyond that there are two particular areas of weakness:

(a) Historical materials related to the river, particularly photographic materials and local surveys: this material can only be uncovered by extensive search and fortuitous discovery. The work is beyond our resources.

(b) Engineering reports and other privately or irregularly published data. Companies, public agencies and individuals may often be willing to provide access for good purpose to materials that are nevertheless not noted or referenced elsewhere. In such cases, we have no means for systematically tracing materials.

CHURCH, M., McLEAN, D.B., KOSTASCHUK, R., TASSONE, B.
1987: Sediment Transport in Lower Fraser River: Summary of Results and Field Excursion Guide.

PREFACE

The studies revieved in this field guide form part of an investigation of the processes governing channel stability and sedimentation in lower Fraser River. A major task is to develop a long term sediment budget for the reach to aid port management below Port Mann. Toward that end, this report gives a review of the available sediment transport observations on the river, which are amongst the more comprehensive available for any river. These have been reconsidered in light of current developments in the analysis of sediment transport measurements. As a result, some aspects of prior analyses have been substantially revised.

It should be realised, however, that the results presented here remain preliminary. They have not been approved by the Water Survey of Canada and should not be regarded as final or authoritative.

A series of reports has been issued to inform the client of progress in this project as follows:

Church, M. McLean, D., Mannerstrom, M. and Evans, D. 1984.
Reference materials on sedimentation and morphology of the lower Fraser River. Environment Canada, Water Resources Branch, Sediment Survey Section.

McLean, D. and Mannerstrom, M. 1985.
History of channel stability: lower Fraser River, Hope to Mission. Environment Canada, Water Resources Branch, Sediment Survey Section.

McLean, D. 1985. Lower Fraser River Survey, 1984:
Agassiz-Rosedale Bridge to Mission. Environment Canada, Water Resources Branch, Sediment Survey Section.

McLean, D. and Church, M. 1986.
A re-examination of sediment transport observations in the lower Fraser River. Environment Canada, Water Resources Branch, Sediment Survey Section.

CHURCH, M., KELLERHALS, R. and WARD, P.R.
1985: Sediment in the Pacific and Yukon Region: Review and Assessment.

SUMMARY OF RECOMMENDATIONS[1]

A. Issues with specific engineering and commercial implications.

B. Studies for improved understanding of sediment transport and deposition process, having general engineering implications.

C. Studies of water quality.

D. Development of standard instrumentation and methods.

E. Procedures in the Sediment Survey Programme.

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[1]Recommendations are in order of priority within, but not between, major categories.

CONSERVATION MANAGEMENT SYSTEMS
1986: Sediment Issues and Data Needs in Ontario, Final Report.

ABSTRACT

This report presents results obtained from a study of sediment issues and programs in Ontario and is one of several reviews across Canada to establish a national perspective on sediment issues and related program needs for Environment Canada. The Ontario study involved the use of a questionnaire and interviews with a cross section of sediment data users and collectors in the province, a one-day workshop of data users, and an extensive literature review. Results are combined, organized and discussed under the heading of sediment issues, knowledge, data and information systems. The report identifies needs and makes recommendations regarding the data base, sampling strategies and methods, and the sediment information system.

NOTE: A French translation of the text of this report is available upon request.

RÉSUMÉ

La présent rapport renferme les résultats d'une étude sur des questions et des programmes relatifs aux sédiments en Ontario. Il s'agit de l'une des nombreuses études menées au Canada pour se doter d'une perspective nationale sur les questions relatives aux sédiments et sur les besoins connexes des programmes d'Environnement Canada. En Ontario, on s'est servi d'un questionnaire et on a mené des entretiens avec un transect d'utilisateurs de données et d'échantillonneurs partout dans la province. On a donné un atelier d'un jour pour les utilisateurs de données et on a fait une revue de littérature exhaustive. Les résultats ont ensuite été compilés, organisés et discutés sous différentes rubriques : questions relatives aux sédiments, connaissances, données et systèmes d'information. Le rapport signale des besoins et renferme des recommandations relativement à la base de données, les stratégies d'échantillonnage et les méthodes connexes, et le système d'information sur les sédiments.

NOTE : On Peut obtenir sur demande la version française du cette rapport.

CONSERVATION MANAGEMENT SYSTEMS
1986: Sediment Issues and Data Needs in Ontario, Executive Summary.

EXECUTIVE SUMMARY

In response to a need expressed by Environment Canada, Conservation Management Systems has undertaken a thorough study of sediment issues and programs in Ontario. This study has involved the use of a questionnaire and interviews with a cross section of sediment data users and collectors in the province, a one-day workshop with representatives from many of the sediment data user groups, and an extensive literature reviev regarding knowledge gleaned from Ontario sediment data. Results from this multifaceted approach to the topic have been combined, organized, and discussed under the headings of: sediment issues, sediment knowledge, and sediment data. The study has led to a clarification of issues relating to sediment, an assessment of knowledge regarding sediment in Ontario, and the identification of needs and recommendations regarding the data base, sampling strategies and methods, and the sediment information system.

CONSERVATION MANAGEMENT SYSTEMS

1985: Ontario Perspectives on Sediment Issues - Phase I, Interim Report.

INTRODUCTION

Background

This interim report presents preliminary results obtained during the first phase of a study of sediment issues and program reviev in the Province of Ontario. Conservation Management Systems vas retained to undertake the study in response to a vish of Environment Canada, Ontario Region, and the Sediment Survey Section of the Water Resources Branch to acquire a better understanding of the role and importance of sediment data in Ontario. Phase I of the study has focused attention on the identification of existing uses of sediment data, evaluation of the data base, and clarification of issues associated vith sediment. The second phase to be undertaken commencing in April 1985, has been planned to assess the state of knovledge regarding sediment and to identify future data needs and approaches to meet those needs. The results emanating from the two phases of this study, vhen assembled vith results from similar studies being undertaken in four other regions of the country (i.e. British Columbia and the Yukon, the Prairies, Quebec, and the Maritimes), are intended to provide a base for the establishment of a national perspective on sediment issues.

Relevance of the Study

It seemed evident at the outset of this study, but has become increasingly clear during Phase I, that the exercise of revieving the sediment program in Ontario is particularly relevant at this time. The existing data base has been assembled nov for upvards of 20 years, a sufficiently long period of record to allov useful analysis and examination of questions such as: What have ve learned? Vhere nov? Much has already been done vith sediment data in the last fev years (e.g. as input to local reservoir and harbour studies, and to regional vater quality projects undertaken under the auspices of groups such as the Pollution from Land Use Activities Reference Group, the Grand River Implementation Committee, and the Thames River Implementation Committee), leading to the development of both temporal and spatial pictures of sediment generation and transport. In light of such vork, it is appropriate to ask: Vhere nov are the gaps in our information and knovledge?

It has also become evident that vhereas sediment data vas used 20 years ago primarily for sediment volume related studies, the data is nov being examined extremely vith regard to quality oriented issues. Further, it is evident that the users of the data are no longer solely engineers

but also biologists, agrologists, geographers, farmers, etc. Therefore, it is indeed timely and important to review the issues, users, and uses associated with sediment in the province, and to resolve the questions: Do present sediment data meet our needs? How should sediment programs be modified to insure that most future needs can be addressed?

DAY, T.J.
1986: Sediment Surveys: It's Time to Yield.

INTRODUCTION

Recent program evaluations have indicated that the Sediment Survey Program of Water Resources Branch must be rationalized and diversified in order to meet the needs of Canadian water resource managers for data, expertise and information.

While sediment is of interest to many Canadian agencies, not one of these appears to have sufficient expertise to address its own concerns, much less provide focus and leadership on a national scale. The proposed new Sediment Survey Program goes beyond mere data collection to give this focus and leadership for sediment and sediment-related concerns in Canada's inland waters.

The proposed changes in the program will result in a network that will continue to be approximately 1/10 of the existing hydrometric network. It will be very specialized, as many aspects of sediment source, transfer and fate (e.g., chemistry, navigation, environmental impacts) must be considered. The program must also pursue its responsibilities to its clients and users agressively and proactively.

DAY, T.J.

1986: WNR Sediment Survey Program: Issues, Network and Recommendations.

INTRODUCTION

The Terms of Reference for the hydrometric network evaluation and planning activities, Appendix I, stated the objectives are to (1) define the adjustments to existing networks and (2) identify additional requirements for streamflow, water level and sediment information in the Western and Northern Region (W&NR).

Initial emphasis was to be given to a definition of the federal responsibility requirements and an evaluation of how well the existing network met those requirements. In addition, the joint federal-provincial and provincial information requirements were to be defined and compared to the ability of existing network to provide that information. Two planning horizons were to be used: 1985 as a definition of present requirements, and 1990 as the near-term future requirements.

As the essence of this review exercise was the establishment of information requirements in W&NR, the evaluation of 'sediment aspects' was based upon the Sediment Survey Program rather than networks only. This distinction is important as this program is delivered through both a 'network' of data collection stations and of studies (e.g. morphological, sediment budgets, relation to ecosystems and water quality).

The information summarized herein was obtained from several sources. First, a questionnaire (Appendix II) was distributed to federal and provincial agencies and a few key individuals (e.g. universities, consulting firms). The questionnaire covered problems, activities, data, information requirements and the guidance required from the Water Resources Branch. Further sources of information were previous program evaluation reports, both regional and national, and from a range of reports which contain either single station or regional data evaluations. Finally, Water Survey of Canada files on data collection programs were used to compile various summary information.

Unfortunately, certain gaps and weaknesses in this information prevented a thorough assessment of the existing program and future needs. Consequently, the Terms of Reference can be met in only a general way. It has been possible only to develop a new sense of direction for the program.

DAY, T.J.
1986: Executive Summaries for Sediment Issues Contracts.

FOREWORD

This report presents the Executive Summaries for each of the five sediment issue reports prepared under contract for the Sediment Survey Section, Water Resources Branch of Inland Waters Directorate. All reports are in final form.

Prefacing the Executive Summaries are notes prepared for Inland Waters Directorate meetings during which the issue reports were discussed. These notes will provide insight into the Sediment Survey Section's initial assessment and reaction to the issue reports. A copy of the existing mandate for the Sediment Survey Program is also included.

DAY, T.J. and SPITZER, M.O.
198.. Sediment Station Analysis: Highwood River near the Mouth, 05BL024.

ABSTRACT

Sediment data were collected at the hydrometric gauging station site, Highwood River near the Mouth, during the period 1970 to 1981 inclusive. The report deals primarily with suspended sediment, but includes information on bed material as well. This report documents the collected data and treats it in various tabular, graphical and statistical ways. It also contains a basin description and photographs taken in the immediate vicinity of the gauging station.

RÉSUMÉ

Les données sur les sédiments ont été relevées à l'emplacement de la station de jaugeage hydrométrique, Highwood River near the Mouth, pendant la période de 1970 à 1981 inclusivement. Les données concernent principalement les relevés de sédiment en suspension; dans certains cas, des informations sur le charriage de fond peuvent être incluses. Ce présent rapport fournit la documentation au sujet des données sous forme de graphiques, de tableaux, et de statistiques. Il y aussi une description du bassin hydrographique, et des photos de l'emplacement de la station.

DEVEAU, J-G.

1988: Atlantic Region Sediment Action Plan - The Next Three Years and Beyond.

ABSTRACT

The Atlantic Region Sediment Action Plan will serve as a guide for the management and operation of the Water Resources Branch sediment programme in the four Atlantic Provinces for the next three years. It gives an overview of the current sediment monitoring situation and provides a time frame for achieving limited changes to bring the existing practices more in line with the recently approved sediment national action plan.

To produce this document, recommendations from the Washburn & Gillis report "Freshwater Sediment Data Collection and Use in the Atlantic Region" and "Proceedings of Charlottetown Sediment Issues Workshop" were utilized, but only to the limit they meshed with the sediment national action plan and were compatible with available resources.

The implementation of several of the recommendations will depend on a large extend on outside factors such as co-operation with the provinces and interest in sediment issues from their part.

RÉSUMÉ

Le plan de travail sédimentologique de la Région de l'Atlantique va servir de guide aux gestionnaires et opérateurs du programme sédimentologique de la Direction des ressources en eau dans les quatre provinces de l'Atlantique. Il donne un apperçu de la situation actuelle en terme d'échantillonage des sédiments et fourni un échéancier pour implanter certains changements afin d'aligner les pratiques courantes avec celles véhiculées dans le plan de travail sédimentologique national récemment approuvé.

Ce document utilise des recommendations des rapports Washburn & Gilles "Freshwater Sediment Data Collection and Use in the Atlantic Region" et "Proceedings of Charlottetown Sediment Issues Workshop" mais seulement en autant que celles-ci soient compatibles avec le plan de travail sédimentologique national et les ressources disponibles.

La mise en oeuvre de plusieurs des recommendations va dépendre en gros sur des facteurs externes tels la collaboration des provinces et l'intérêt qu'elles porteront aux questions sédimentologiques.

FRENETTE, M., BARBEAU, C., and VERRETTE, J.-Ls.
1989: Aspects Quantitatifs, Dynamiques et Qualitatifs des Sédiments du Saint-Laurent

RÉSUMÉ

Le présent document constitue une compilation et une mise à jour des données disponibles sur les sédiments du Saint-Laurent, intégrées et analysées sous trois thèmes différents: aspects quantitatifs, dynamiques et qualitatifs. Des recherches particulières et une modélisation mathématique ont également servi de support à plusieurs énoncés du contenu. Les données sont fournies selon divers modes de présentation puis synthétisées dans huit planches caractérisant les principaux traits dominants du fleuve sur le plan sédimentologique. L'information contenue dans ce document facilitera l'évaluation environnementale et le programme de protection et de mise en valeur du Saint-Laurent.

ABSTRACT

This report is a compilation of the available data on the sediments of the St. Lawrence River, intergrated and analysed under three different themes: quantitative, dynamic and qualitative aspects. Particular researches and mathematical modelling have provided support for several statements. The data are presented in various formats and synthesized in eight general drafts caracteryzing the main features of the St. Lawrence in regard to the sedimentological aspects. The information contained in the report shall help the environmental evaluation and the programme of protection and of development of the St. Lawrence River.

GLAVIC, H., DAY, T.J., YUZYK, T.R.

1988: Interpretation of Suspended Sediment Characteristics, Red River at Emerson, Manitoba, 1978-1986.

ABSTRACT

There is a groving avareness that fine suspended sediments are a prime media for the transport and storage of many contaminants. Within the Inland Waters Directorate. Water Quality and Water Resources Branches have responsibilities for monitoring contaminants and suspended sediments respectively. This report, which provides a summary and interpretation of existing suspended sediment data, is the first of several planned for the Red River at Emerson, Manitoba. Sampling strategies, methodologies, equipment, computational procedures and data have been evaluated with the objective of determining how the two Branches can work more effectively together.

Meaningful suspended sediment monitoring at Emerson, Manitoba on the Red River began in 1978 with both Water Survey of Canada (WSC) and the United States Geological Survey (USGS) initiating sampling programs. The WSC program provides data on a flow-weighted basis, year round, while the USGS program collects monthly samples only. Earlier, Prairie Farm Rehabilitation Administration sampled suspended sediments during open water in 1956 and 1961.

Based upon WSC data, the mean annual suspended sediment load is 886 000 tonnes for the period 1978-1986, when the mean annual flow was 39.5% higher than the historical average. The annual distribution of load is not typical as 40% of the suspended load is transported during the June to August period. A general counter-clockwise hysteesis exists in the concentration-discharge which arises from the high summer concentrations.

Suspended sediments are silt and clay which result in quite homogeneous concentrations and particle sizes in the measurement cross sections. The bed and bank materials are of similar composition.

Finally, data collected by WSC and USGS are shown to be quite compatible and that the two data sets can be used interchangeably. Recommendations regarding the sampling program are put forth which will aid subsequent analyses.

RÉSUMÉ

On prend de plus en plus conscience que le fines particules des sédiments ene suspension constituent l'un des principaux moyens de transport et de stockage de nombreux contaminants. La Direction de la qualité des eaux et celle des ressources en eau, au sein de la Direction générale des eaux intérieures, sont chargés respectivement de surveiller les contaminants et les sédiments en suspension. Le présent rapport, qui résume les données disponibles au sujet des sédiments en suspension et en fait l'interprétation, constitute le premier d'une série prévue pour la rivière Rouge à Emerson, au Manitoba. On y évalue les stratégies, les

méthodes et le matériel d'échantillonnage ainsi que les méthodes de calcul et les données afin d'établir comment les deux directions peuvent mieux collaborer dans leur travail.

Une surveillance significative des sédiments en suspension à Emerson (Manitoba), sur la rivière Rouge, a débuté en 1978 alors que les Relevés hydrologiques du Canada (RHC) et le United States Geological Survey (USGS) y ont tous deux entrepis un programme d'échantillonnage. Le programme des RHC fournit des données pondérées en fonction du débit, tout au long de l'année, tandis que celui de l'USGS prévoit seulement le prélèvement mensuel d'échantillons. Auparavant, l'Administration du rétablissement agricole des Prairies a échantillonné les sédiments en suspension durant les périodes d'eaux libres en 1956 et 1961.

Calculé à partir des données des RHC, le transport annuel moyen des sédiments en suspension entre 1978 et 1986 est de 886 000 tonnes, tandis que le débit annuel moyen était de 39,5 % de plus que la moyenne historique. La distribution annuelle du transport n'est pas caractéristique, car 40 % des matières en suspension sont transportées de juin à août. Une hystérésis générale dans le sens indirect est observée dans la relation entre la concentration et le débit qui est causée par les fortes concentrations enregistrées durant l'été.

Les sédiments en suspension se composent de limon et d'argile d'où la concentration et la granulométrie assez homogènes dans les sections mouillées servant au prélèvement des échantillons. Les matériaux du lit et du rivage sont d'une composition semblable.

Enfin, les données recueillies par les RHC et le USGS sont assez compatibles, et les deux ensembles de données peuvent être utilisés de façon interchangeable.

Les recommandations formulées au sujet du programme d'échantillonnage faciliteront les analyses ultérieures.

HARDY BBT LIMITED
1989: Sediment Station Analysis: South Saskatchevan River at Saskatoon 05HG001

ABSTRACT

This is one of a series of sediment station analysis reports issued by the Water Resources Branch of Environment Canada. The report was prepared by Hardy BBT Limited under contract to the Department of Supply and Services. It presents a summary and analysis of the sediment data for the South Saskatchevan River at Saskatoon, Saskatchevan (Sta. 05HG001, for the period 1961 - 1971, and 1975). The data have also been assessed in terms of the impacts of the Gardiner Dam, channel morphology and effects on Codette Reservoir sedimentation.

Notwithstanding the general reduction in sediment loads resulting from the operation of Gardiner Dam, the data base indicates that substantial suspended sediment loads can be transported past Saskatoon. This may affect the projected life expectancies for Codette Reservoir and Tobin Lake.

It has been concluded that the available sediment data on the South Saskatchevan River at Saskatoon sufficiently describe the annual and monthly sediment regime. However, the data base appears to be deficient in fully describing the flow regimes for higher flows, and especially the trap efficiency of Gardiner Dam.

It is recommended that the sediment data collection program on the South Saskatchevan River at Saskatoon be re-established on a special event basis to document sediment discharges for flows >1500 m^3/s. Suspended sediment particle size data should also be collected to determine the type of material being transported.

RÉSUMÉ

Une réalisation de la société Hardy BBT Limited dans le cadre d'un marché conclu avec le ministère des Approvisionnements et Services, le présent rapport constitue l'un d'une série de rapports d'analyse concernant des stations d'étude des sédiments publié par la Direction des ressources en eau d'Environnement Canada. Le rapport présente un sommaire et une analyse des données relatives aux sédiments de la rivière Saskatchevan Sud à Saskatoon, en Saskatchevan (station 05HG001, de 1961 à 1971 et en 1975). Les données ont également été évaluées en rapport aux répercussions du barrage Gardiner, à la morphologie du chenal et aux effets sur la sédimentation du réservoir Codette.

Malgré la diminution générale du charriage de fond entraînée par le fonctionnement du barrage Gardiner, les données de base indiquent que des quantités importantes de matières en suspension sont transportées au-delà de Saskatoon. Ce phénomène pourrait affecter les durées de vie utile projetées pour le réservoir Codette et le lac Tobin.

Il a été conclu que les données disponibles sur les sédiments de la rivière Saskatchevan Sud à Saskatoon permettent de décrire suffisamment le régime annuel et mensuel des sédiments. Toutefois, la base de données semble être inadéquate, car elle empêche de décrire entièrement le régime d'écoulement pour des débits plus élevés et, tout particulièrement, l'efficacité du barrage Gardiner à retenir les sédiments.

Il est recommandé de réétablir le programme de collecte de données sur la rivière Saskatchevan Sud, à Saskatoon, de façon à tenir compte des événements spéciaux et permettre de documenter les débits solides pour des débits supérieurs à 1500 m^3/s. Les données sur la granulométrie des sédiments en suspension devraient aussi être recueillies afin de préciser le type de matières transportées.

HARDY BBT LIMITED
1989: Sediment Transport Analysis: Lesser Slave Basin Volume 1.

ABSTRACT

Sediment data have been collected in the Lesser Slave Lake basin since 1969. These data have been collected at six sites. The objective of the data collection program was to provide sediment data for engineering applications such as the effects of channelization, the monitoring of land use changes, and for use in the development of a management plan for the Buffalo Bay area.

This report contains a review of all the available sediment data in the basin and provides an analysis of these data with respect to their potential use. The sediment budget of Lesser Slave Lake is evaluated and the sediment issues in the basin are discussed.

The report concludes that sufficient information is available at four of the six sites and recommends these be discontinued. The report also recommends that the Swan River near Kinuso site be maintained but that the sediment program be downgraded to a partial program. However the report does recommend the establishment of a partial program station on the Lesser Slave River at the outlet of Lesser Slave Lake in order to determine the rate of littoral supply to the outlet channel.

The report has been printed in two volumes; the first volume containing a summary of the analyses performed, whereas the second volume describes the analyses in greater detail. Volume two contains a variety of figures and tables which characterize the sediment data for each of the six sediment stations.

RÉSUMÉ

Des données de sédiments ont été récoltés dans le bassin du Lac Lesser Slave (Petit Lac des Esclaves) depuis 1969. Ces données ont été récoltées en six sites. L'objectif général de ce programme de collection de données était de pourvoir des données de sédiments pour applications du génie, telles que les effets de canalisation, le contrôle des changements d'utilisation du terrain, et comme outil pour le développement d'un plan d'exploitation de la région de la baie de Buffalo.

Ce rapport contient une revue de toutes les données de sédiments disponibles pour ce bassin et présente une analyse de ces données en égart à leurs applications potentielles. Le budget sédimentaire du Lac Lesser Slave y est évalué et les questions de sédiments discutées.

Le rapport conclut que l'information disponible est suffisante pour quatre des six sites et recommande que ces derniers soient discontinués. Ce rapport recommande aussi le maintient du programme sédimentaire au site de la rivière Swan (du Cygne) près de Kinuso mais à titre de programme partiel. Il conseille de plus l'établissement d'un programme de station

partielle sur la Rivière Lesser Slave (Petite Rivière des Esclaves) à l'embouchure du Lac Lesser Slave en vue de déterminer le taux de sédiments générés à partir du littoral jusqu'au canal de déversement.

Le rapport a été publié en deux volumes; le premier volume présente un résumé des analyses effectuées alors que le second volume décrit les analyses de façon plus détaillée. Ce second volume contient un ensemble de figures et de tableaux caractérisant chacun des groupes de données sédimentaires pour les six stations.

HARDY BBT LIMITED
1989: Sediment Transport Analysis: Lesser Slave Basin Volume 2.

INTRODUCTION

This is the second of two volumes of a report on the sediment transport in the Lesser Slave Lake basin.

The objectives of the study are to analyze the sediment data collected by Water Survey of Canada in the basin and to assess the sufficiency of the data base for calculating sediment transport into and out of Lesser Slave Lake. The adequacy of this data base for engineering, contaminant transport, and environmental purposes are also to be assessed.

This volume, a data report, contains a review of the sediment data available at each of the monitoring station and a characterization of the sediment regime at each station. A review of the discharge regime is also presented for each site since an understanding of the discharge regime is fundamental to understanding the sediment regime. Any deficiencies in the existing data for each site are presented, along with an assessment of the representativity of the data.

The material which follows is presented in a common format for each site, starting with a general description of the site, followed by a description of the discharge regime, then by a critical review of the sediment data collection program, a summary of the sediment loads, concentrations, and sediment size characteristics, and finally a review of the dissolved solids data.

Volume 1, the final report, synthesizes the information presented in the present volume on a regional basis and assesses the adequacy of the sediment monitoring program with regard to engineering, water quality, and environmental applications. A sediment budget of Lesser Slave Lake is also presented along with recommendations for future program activities.

HIRST, S.M., MILES, M., BLACHUT, S.P., GOULET, L.A., TAYLOR, R.E.
1988: Quantitative Synthesis of the Mackenzie Delta Ecosystems.

ABSTRACT

The Mackenzie delta, Northwest Territories, has an area of some 13,000 km² and is the second largest delta in North America. It receives the discharge from a watershed of about 1,900,000 km² in extent, comprising 11 major drainage basins.

The report presents a quantitative synthesis of the ecosystems of the Mackenzie delta. The objective of the synthesis is to examine the structure and relative sensitivity of ecosystem components and processes within the Mackenzie delta, and to identify significant information gaps.

Most of the information in the synthesis is drawn from studies undertaken by B.C. Hydro from 1980 through 1983. A total of 36 B.C. Hydro source reports, 33 of which deal with the Mackenzie delta, 2 with the Beaufort Sea and 1 with socio-economic concens, are listed in an appendix. A keyword index provides a listing of all physical and biological data contained in the source reports. Supplementary information has been taken from other recent studies and from the literature.

RÉSUMÉ

Le delta du Mackenzie, dans les Territoires du Nord-Ouest, s'entend sur une superficie de quelque 13 000 km²et est le deuxième delta en importance en Amérieuq du Nord. Il reçoit le débit en provenance d'un bassin hydrographique d'une étendue approximative de 1 900 000 km² qui regroupe 11 grands bassins.

Le présent rapport fait la synthèse quantitative des écosystèmes du delta du Mackenzie. Cette synthèse vise à examiner la structure et la sensibilité relative des éléments et processus des écosystèmes présents dans le delta et d'identifier les lacunes importantes au chapitre des données.

La plupart des rensignements contenus dans cette synthèse proviennent d'études réalisés par la B.C. Hydro et 1980 à 1983. Trente-six rapports de la B.C. Hydro sont cités en annexe, soit 33 portant sur le delta du Mackenzie, 2 sur la mer de Beaufort et 1 sur des préoccupations d'ordre socio-économique. Un index de mots clés donne la liste exhaustive des données physiques et biologiques contenues dans les rapports. Des renseignements additionnées, tirés d'études récentes et d'autres documents, complètent le rapport.

HUDSON, H.R. and ASKIN, R.W.

1987: An Interpretive Study of the Upper Oldman River Sediment Regime.

ABSTRACT

Sediment sources and controls on suspended sediment transport are examined in the Oldman River basin above Brocket in Southwestern Alberta. The major sediment sources in the 4 400 km^2 river basin were isolated by constructing a sediment budget from existing sediment records, delimiting sediment sources using aerial photograph and site inspections, and constructing topographic maps of major erosion sites from 1965 and 1985 aerial photographs to calculate erosion losses. Additional inferences on sediment sources were gained from a comparison of particle size distributions, cesium-137 content, and petrographic variations from sediment sources, river channel deposits and sediment load at the Brocket hydrometric station. This information was combined with a description of physiography and climatology to interpret the suspended sediment regime of the Upper Oldman River basin.

The annual suspended sediment load of the Oldman River near Brocket (05AA024) is about 275 000 tonnes, with a standard error of estimate of 30 percent. The sediment budget indicated that the major suspended sediment contribution areas in the Upper Oldman River basin are, in order of importance: (1) the lower basin area of the Oldman, Castle and Crowsnest Rivers (about 190 000 t/y); (2) the Castle River foothills and mountains (40 000 t/y); (3) the Oldman River above Waldron's Corner (34 000 t/y); (4) Mill Creek (6 000 t/y); and (5) the Crowsnest River above Frank (4 000 t/y). These estimates are based on fewer data, and are less reliable than the annual load estimate at Brocket.

The sediment regime of the Oldman River near Brocket is explicable in terms of the interaction between the hydrologic response and sediment sources. Smaller magnitude annual floods are generated largely from snowmelt in the foothills and mountains. As the magnitude of the flood increases, the rainfall component tends to increase and the contributing area expands to include the plains. The largest floods occur with heavy rainfall in the spring when the ground is saturated and snowmelt runoff occurs.

The Cardston Plain area dominates the sediment yield of the Upper Oldman River basin above Brocket. Sediment is derived from gully erosion and tributary channel enlargement and incision to base level on the plains, toe erosion of large mass movement deposits which impinge upon the river channel, and general channel erosion. Erosion occurs mainly in the spring as the result of snowmelt and/or rainfall. Occasionally, in the summer during the snowmelt recession of the Oldman River, heavy rainfall may generate pulses of sediment from the plains.

Upland contributions from the mountains and foothills are limited because of the forest cover and limitations in fine sediment supply. The major sediment sources and processes in these areas are surface wash of

non-vegetated colluvial slopes, and channel and riparian erosion. Runoff from the barren colluvial slopes is generated largely by snowmelt over a period of days to weeks in the spring and generally coincides with the annual flood of the Upper Oldman River. Sediment contributions from channel and riparian sources occur as the result of flushing of readily erodible material at the toe of the river banks and valley walls. The material is sediment supply limited, which accounts for the high initial sediment concentrations on the rising limb of the flood hydrograph and the decreases in concentration with subsequent hydrograph rises. Conceptual descriptions of the processes are presented to describe these relationships.

As a result of these controls, the bulk of the annual suspended sediment transport of the Upper Oldman River occurs in a short period during the annual flood. Subsequent flood peaks contribute progressively less material as the result of sediment supply exhaustion. In some cases, high sediment loads may occur following the spring flood peak as the result of largely rainfall generated floods which cause bank erosion or upland riparian erosion.

An evaluation of methodologies employed in this interpretation of the sediment regime of the Upper Oldman River basin indicates the following:

(1) Good quality sediment records are essential in any such study, preferably at several relevant locations upstream. These records should be available in the form of the report presented by Day and Spitzer (1985), "Sediment Station Analysis, Oldman River Near Brocket".

(2) Aerial photographic reconnaissance can provide a good overview of sediment sources in a drainage basin. However, field inspection revealed a number of difficulties in interpretation in this study, and in previous work. Thus, field inspection is essential in any such future studies.

(3) Detailed topographic mapping from sequential aerial photographs provides a cost effective means of quantifying point source contributions and indicates where this erosion occurs, which is essential for inferring erosion processes.

(4) The analysis of sediment attributes such as particle size distributions, cesion-137 content, and petrographic variations of sediment sources, channel deposits and sediment yield from the basin, provide support for the interpretation developed using the aforementioned approaches.

(5) The major limitation to this type of study is that erosion processes have to be inferred from various lines of evidence. The accuracy of these inferences is dependent on the experience of the observer.

HYDROCON ENGINEERING (Continental) LTD.
1987: Sediment Station Analysis: Pembina River near Windygates 050B007.

ABSTRACT

This is one of a series of sediment station analysis reports issued by the Water Resources Branch of Environment Canada. It presents a summary and analysis of the sediment data for the Pembina River near Windygates, Manitoba, (Sta. 050B007), for the period 1962-1984. The data have also been assessed in terms of the use of sediment rating curves, water quality concerns, and reservoir sedimentation studies.

It has been concluded that the available sediment data on the Pembina River near Windygates sufficiently describe the present sediment regime, and that the detailed sediment data collection program should be suspended. It is recommended that a miscellaneous sediment data collection program should be suspended. It is recommended that a miscellaneous sediment data collection program be instituted, which could run in conjunction with a short-term water quality sampling program aimed at studying organic contaminant loading. The miscellaneous program should also aim to measure suspended sediment concentrations for extreme high and low flows, as well as particle sizes for low concentrations.

HYDROCON ENGINEERING (Continental) LTD.

1987: Sediment Station Analysis: Red Deer River at Red Deer (05CC002), at Drumheller (05CE001), near Bindless (05CK004).

ABSTRACT

The Water Resources Branch of Environment Canada has operated major sediment data collection programs on the Red Deer River, at Red Deer, at Drumheller and near Bindloss, which was established, respectively, to monitor sediment discharge for reservoir planning, to determine sediment laods due to contribution from the Badlands, and to assist in determining sediment loads into Lake Diefenbaker.

Data from all three sites, from 1966 until suspension of the detailed monitoring programs at the end of 1984, has been analysed and summarized. Based on these analyses, it has beenconcluded that the suspended sediment transport characteristics and sediment yield of the Red Deer River at Red Deer, at Drumheller and near Bindloss generally have been well documented by the existing data base. Further intensive data collection will not improve the overall understanding of suspended sediment transport at these sites. However, as discharges during the detailed sediment sampling period were lower than long-term mean flows, future miscellaneous data collection programs should attempt to measure loads for extreme events beyond those covered by the present data base.

This report also evaluated the suspended sediment transport regime of the Red Deer River, and identified trens and patterns in the data between the three sites. Sediment yield from the Badlands and throughout the river basin in general was discussed, and the long-term effects of Dickson Dam operation on sediment transport was examined and found to be minimal.

RÉSUMÉ

L'agence de Resource des Eaux d'Environnement Canada a conduit d'importants programmes de collection de données sur les sédiments de la rivière Red Deer à Red Deer, Drumheller et près de Bindloss. Ces programmes avaient pout but, respectivement, de contrôler les déchargements de sédiment pour la planification d'un réseroir, de déterminer le chargement de sédiment dû à la contribution des Badlands, et d'assister à la détermination du chargement de sédiment dans le lac Diefenbaker.

Les données recueillies sur ces trois sites, depuis 1966 jusqu'à la suspension du programme de contrôle détaillé à la fin de 1984, ont été analysées et résumées. Basé sur cette analyse, il a été conclu que les charactéristiques de transport de sédiment supendu et l,apport de sédiment de la rivière Red Deer à Red Deer, à Drumheller et près de Bindloss ont été généralement bien documentées par la banque de données existante. Une collection plus intensive de données n'améliorerait pas la compréhension générale du transport de sédiment suspendu. Cependent, étant donné que les déchargements durant la période d'échantillonnage détaillé de sédiment était inférieurs à l'écoulement moyen à long terme un programme de

collection de diverses données deurait à l'avenir essayer de mesurer les chargements pour les événements extrêmes au-delà de ceux qui ont été couverts par la présente banque de données.

Ce rapport évalue également le régime de transport de sédiment suspendu de la rivière Red Deer et identifie les tendances de données entre les trois sites. L'apport de sédiment des Badlands, et au travers du bassin de la rivière en général est discuté. Les effets à long terme des opérations effectuées sur le barrage Dickson sur le transport de sédiment ont été examinés et il a été trouvé que ces effets sont minimes.

HYDROQUAL CONSULTANTS INC.
1986: Total Dissolved Solids Trends in the Saskatchevan River Basin.

SUMMARY

The Water Resources and Water Quality Branches of Environment Canada have, over the past three decades collected total dissolved solids (TDS) data from surface waters throughout the Saskatchevan River Basin. The Water Resources Branch (WRB) collects TDS as an adjunct to their sediment monitoring program, for the purpose of calculating geochemical yield. Water Quality Branch (WQB) collects TDS samples at their fixed river monitoring stations, and at special project sites, for definition of baseline conditions and assessment of trend in concentrations.

The total database consists of 33,585 samples, which includes 9,771 samples collected by WQB and 23,814 by WRB. Data have been collected at 223 locations. Water Quality Branch has data for 180 sites, WRB for 85 sites and there are 42 sites which overlap. The database is extensive, i.e. greater than 100 samples over at least 5 years, for 64 of the 223 total sites. Thirty-one of these long-term sites are actively sampled by one or other agency. Out of a total of 57 active stations, only 5 sites are currently sampled by both agencies.

The historical database generally covers the entire basin adequately, with a few minor exceptions including the northern tributaries of the main-stem Saskatchewan River and the South Saskatchewan River downstream of the Alberta border. A large proportion of the total sites sampled, 106 of 223, are located along the east slopes of the Rocky Mountains.

The daily TDS concentration of rivers in the Saskatchewan basin can be adequately characterized by one depth integrated sample collected at mid-channel. There is no need for a multiple-vertical sampling strategy, as is required for suspended solids. This means that despite differences in sampling strategy between WRB and WQB, this factor does not need to be accounted for when combining data from both sources. However, WQB data should be multiplied by 1.055 to compensate for analytical differences. WQB estimates TDS by sum of ions, whereas WRB used a direct gravimetric technique.

The TDS record at many points in the basin is substantial, and permits powerful time series analyses. WQB data, which follows a fixed monthly schedule, is more useful in this respect than WRB data which emphasizes high flows and open-water months. The principal long-term trends in TDS concentrations across the basin relate to flow regulation on the North and South Saskatchewan Rivers, which depresses the natural winter TDS maximum, and reduces the annual variance in concentration. More subtle effects from altered land use or increased effluent loadings are not apparent on the South Saskatchewan at Highway 41, or the Red Deer River at Bindloss, but a trend of slowly increasing TDS concentration is detectable on the lower Bow River. Municipal wastes or irrigation return flow are probably responsible for this increase. Dams recently completed or under construction on the Red Deer and Oldman Rivers are expected to

disrupt the annual TDS pattern in a manner similar to that experienced by the other regulated rivers in the basin.

In both the ice-cover and open-water seasons, there is a general increase in tributary TDS concentrations from west to east, with concentrations being low in the western sub-basins, intermediate for the North Saskatchewan and Battle sub-basins and high in the eastern sub-basins draining Saskatchewan and Manitoba. The first TDS means >500 mg/L are found in prairie streams at least 100 km east of the mountains. At the opposite end of the basin, in eastern Saskatchewan, concentrations are seldom <500 mg/L and values >1000 mg/L are commonplace.

Main-stem rivers had a nearly constant mean TDS concentration across the basin, ranging between 200 and 300 mg/L, with only a subtle increase from west to east. This trend indicates that dilute mountain runoff dominates main-stem river water concentrations throughout the basin, despite the influx of ion-rich water from the tributaries. The higher main-stem concentrations in the Battle River arise because this sub-basin, and no other, is free of the influence of mountain runoff.

Geochemical loads calculated from WQB data, WRB data or all data combined usually differ by 10% or less, except in winter when under-sampling by Water Resources Branch causes inflated loading estimates. For all other seasons, or annual estimates, data from either Branch will produce reliable results. At most locations, sampling for 10 years will produce estimates of mean TDS loads with a standard error of 10-15%. Sampling beyond this limit will not improve precision of the loading estimate; unless information on changes in load through time is required.

Most of the annual TDS load is carried during the open-water season; the small proportion carried during ice-cover increases with increasing regulation of stream flow. Rates of geochemical yield are greatest for the mountain and foothill areas relative to the prairies.

HYDROTECH INC.

1985: Etat de connaissance et prospectives sedimentologiques des eaux douces du Québec.

SOMMAIRE EXECUTIF

Depuis 1968, il y a eu, au Québec, une collection importante de données sédimentologiques qui s'est intensifiée à partir de 1969, avec l'impltation d'un réseau de base sédimentologique, réparti sur plusieurs bassins de cours d'eau. A partir de 1970, le nombre de bassins jaugés diminua graduellement pour cesser d'être opérationnel depuis 1982. Parmi les raisons qui ont entraîné l'abandon des relevés, outre les facteurs coût des opérations et difficultés de prélèvements, il y a le fait que nombre de données étaient mal utilisées ou inutilisées à cause de l'absence de liens entre les programmes de relevés et les besoins des usagers.

JORDAN, P.
1987: Impacts of Mass Movement Events on Rivers in the Southern Coast Mountains, British Columbia: Summary Report.

ABSTRACT

A study has been conducted in the southern Coast Mountains of British Columbia to investigate the impact of terrain hazards on the geomorphology and flood hydrology of rivers. Such hazards include debris flows, slope failures in unconsolidated material and bedrock, and the drainage of moraine- or ice-dammed lakes. Impacts are most frequently due to the sudden introduction of large quantities of coarse sediment to a river channel. In rare cases, complete blockage of a river channel by a landslide or debris flow can be followed by an outburst flood.

A system for the classification and mapping of terrain hazards and their impacts on river channels has been proposed, and applied to a representative study area, the Squamish and Lillooet watersheds. In this study area, the most frequent and most severe impacts result from landslides and debris flows in Quaternary volcanic complexes. Most other river channel impacts result from debris flows originating in small, steep tributary basins. The potential for large slope failures which could completely block main-stem rivers exists in several locations. Although no longer a significant hazard in the study area, outburst floods from moraine- or ice-dammed lakes present potential hazards elsewhere in the Coast Mountains.

RÉSUMÉ

On a réalisé une étude dans la chaîne côtière du Sud en Colombie-Britannique afin d'examiner les effets des accidents de terrain sur la géomorphologie et l'hydrologie des cours d'eau en période de crue. On entent par de tels accidents des coulées de débris, l'éboulement de matériaux non consolidés et de la roche-mère, ainsi que le drainage de lacs de barrage par moraine ou de lacs de barrage glaciaire. L'introduction soudaine de grandes quantités de sédiments grossiers dans le chenal d'un cours d'eau entraîne le plus souvent ces effets. Dans de rares cas, un glissement de terrain ou l'écoulement de débris peut bloquer complètement le cours d'eau, et une inondation subite peut s'ensuivre.

On a proposé un système visant à classifier et à cartographier les accidents de terrain et leur incidences sur les chenaux des cours d'eau et on l'a appliqué à une région d'étude représentative, celle des bassins versants des rivières Squamish et Lillooet. Dans cette région, les incidences les plus fréquentes et les plus graves sont dues à des glissements de terrain et à des coulées de débris dans les complexes volcaniques du Quaternaire. Des coulées de débris en provenance de petits bassins tributaires profonds sont la cause de la plupart des autres incidences sur les chenaux. De graves éboulements qui bloqueraient entièrement les branches principales de cours d'eau pourraient se produire à plusieurs endroits. Bien que les inondations subites dues à des lacs de barrage par moraine ou à des lacs de barrage glaciaire ne présentent plus de dangers potentiels ailleurs dans la chaîne cotière.

KELLERHALS ENGINEERING SERVICES LTD.
1988: Morphological Effects of the Churchill River Diversion, Volume 2, Feasibility Study and Monitoring Recommendations.

ABSTRACT

The present report is Volume 2 of a two volume series and discusses the second phase of a study on the changes in river morphology which have resulted from the Churchill River Diversion. In Volume 1 morphological effects are discussed on the basis of data and reports available in Spring 1987, combined with the results of a brief field inspection. Future morphological monitoring requirements are discussed in relatively general terms and recommendations are made for several office studies to develop a detailed field and office monitoring program. These studies have now been carried out and their results are reported here.

Since completion of Volume 1, several directly relevant studies have been made available. They are reviewed here in Section 2. Manitoba Hydro's study of the open-water hydraulics of the diversion route between the Notigi Control Structure and Split Lake confirms that erosion along the channelized part of the diversion route is not causing large-scale morphologicalchanges. Effects on water levels are mostly quite localized, however the post-diversion water levels of Birchtree and Opegano Lakes have dropped by 0.8 and 1.2 m, respectively, due to erosion at the controlling channel sections. Erosion on a scale to affect flows and water levels is clearly limited to some of the major rapids. The Symbion Consultants study of the extent of flooding in the Nelson House Trapping Block, undertaken for the Northern Flood Committee, tabulating the results are different and the studies are therefore difficult to compare.

Investigating the feasibility of using maps and air photos to quantify morphologic changes is one of the main objectives of this study. In Volume 1 shoreline stability, flooding, floating debris, standing dead trees, and areas of shallow water depth are identified as the morphologic changes of most direct relevance to the Northern Flood Committee Bands. Using air photos of Footprint and Threepoint Lakes, we now show that these features can be quantified in a useful manner. The results show drastic changes, particularly in shoreline stability and in the extent of debris-clogged water. Longterm changes in these parameters are also of scientific interest. The results of the present study could be improved considerably by conducting field work to ground truth the air photo interpretations and by obtaining air photos and video documentation flown specifically for this type of application.

Besides trying to determine the areal extent of the effects mentioned above, erosion volumes are also estimated for a few severely eroding sites. The objective was to determine the feasibility of quantifying erosion rates on the basis of air photo interpretation and to compare the calculated erosion volumes with the preliminary sediment budget for the Churchill River Diversion (based on 1977-1978 data) discussed in the companion study on sediment transport undertaken by Northwest Hydraulic Consultants.

The results of this investigation, presented in Section 3, indicate that sufficient photography is available to allow the determination of erosion rates at sites undergoing relatively rapid rates of retreat. Analyses of sites fully exposed to wave erosion on southern Footprint and Wuskwatim Lake indicate no detectable shoreline erosion occurred over the period between the mid-1950's and the early 1970's. Following completion of the Churchill Diversion, rates of shoreline erosion increased dramatically, with average recession at the study sites ranging from 2 to 3 m/yr. This corresponds to an annual sediment production of approximately 6 m^3/yr per linear metre of shoreline eroded.

Rates of shoreline erosion were also estimated along two river reaches containing sections of rapids. Data from Gods, Caribou and Early Morning Rapids (located between Threepoint and Wuskwatim Lakes) indicate that, while no detectable erosion occurred in the 1954 to 1970 period, shoreline recession appears to have produced an average of 1.6 to 6.5 x 10^4 tonnes/yr of sediment in the period 1977 to 1981 and 1.2 to 4.8 x 10^4 tonnes/yr in the period 1981 to 1985. This average 1977 to 1981 erosion volume represents 6 to 22 per cent of the estimated annual sediment entrainment in the area between the inlet to Threepoint Lake and the exit of Wuskwatim Lake. The comparatively small amount of material being eroded from this section of rapid, combined with the documented high rates of shoreline recession on Wuskwatim and Footprint Lakes, suggests that much of the sediment entrained in the above reach is coming from lake shore erosion, possibly with a significant contribution from the upper Burntwood River.

Similar erosion studies were conducted at First Rapids (located 14 km upstream of the confluence of the Burntwood River and the Odei River). These analyses indicate that substantial increases in rates of erosion occurred following the Churchill Diversion. Average sediment production at this site during the period 1977 to 1981 is estimated to be 2.2 to 9.7 x 10^4 tonnes/yr. This represents 14 to 65 per cent of the estimated annaul sediment entrainment in the reach between First Rapids and Manasan Falls. Shoreline erosion is also occurring in the vicinity of Second and Third Rapids and it therefore appears that localized bank erosion is an important sediment source in the lower section of Burntwood River.

Morphological changes along the lower Churchill River are addressed briefly in Section 4 and found to be developing slowly. Although the river will eventually look very different from its present state, both the stable, bedrock-controlled nature of the river channel and the harsh climate of the area assure that changes are taking place at a very slow rate.

The Churchill River diversion has had such widespread effects that there are many morphological parameters undergoing change and they could all be monitored. In Section 5 we discuss how the significant morphological changes arising from the diversion could be monitored and then try to attach priorities from two perspectives. The proposed studies are first rated by what we estimate to be the requirements of the Northern Flood Committee, which we see as quantifying those changes that affect their band members (e.g., changes in shoreline stability, floating debris, sedimentation of fish spawning areas, etc.). The second priority

rating is based on the potential contribution of any study to the general scientific understanding of the processes involved. In addition, all studies are rated by the degree to which residents of the study area might be involved in the monitoring work.

As the morphological monitoring program for the diversion route has to be planned to accommodate Manitoba Hydro's proposed three further hydro-electric developments, the recommended field sites have been preferentially located above and below the potential reservoir areas. However, the three projects, for which forebay elevations and operating regimes are only ill-defined at present, will clearly have major morphological effects. To some extent the data relevant to predicting the environmental impacts of the additional dam sites. Some pre-project "base-line" monitoring may be desirable however and, once any of these proposals reach the construction stage, there will be a need for further, project-specific, morphological monitoring.

Since the morphological studies outlined in Section 5 tend to be very expensive - clearly too expensive to be carried out under the ongoing federal ecological monitoring program, we are recommending a scaled-down, minimal morphological monitoring program, concentrating on areas and issues most relevant to the residents of Nelson House and Split Lake. This program would provide reasonably detailed quantitative morphologic data for Threepoint and Footprint Lakes and for the Burntwood River between First Rapids and Split Lake. The proposed studies would cost on the order of $50,000. Some results would be of immediate use but, to gain maximum benefits from such a program, it would need to be repeated several times at intervals of 5 to 10 years.

KELLERHALS ENGINEERING SERVICES LTD.
1984: Review of Sediment Survey Program, Lower Fraser River, British Columbia.

INTRODUCTION

The Fraser River originates in the Rocky Mountains some 30 km southwest of Jasper and drains 233,000 km^2 of south-central and south-western British Columbia to the Straight of Georgia. The term "Lower Fraser River" generally refers either to the lovermost 190 km navigable reach of the river from Yale (at the mouth of the Fraser Canyon) to Sand Heads (a navigation light at the outer edge of the delta) or to the somewhat shorter (165 km) alluvial reach from Hope to Sand Heads. This latter reach corresponds to the present study area.

Continuous flow and sediment transport data are available for four sites along the lower Fraser, although occasional data have been obtained elsewhere (Zyrmiak, 1982; Church et al., 1984). The four sites, with the corresponding distances from Sand Heads along the thalveg, are Hope - km 165, Agassiz - km 130, Mission - km 84, and Port Mann - km 43. A detailed discussion of data available in 1984 is presented subsequently in Section 2.

The runoff regime of the Fraser River at Hope is snovmelt dominated. Over the seventy-one years of continuous flow records at Hope, annual peaks have ranged from 5130 m^3/s to 15,600 m^3/s, with a mean of 9600 m^3/s, and have occurred between May 1 and July 16.

The annual low flows range from 340 m^3/s to around 900 m^3/s and occur between late November and early April. Mean annual runoff is 86.2×10^6 dm^3 over the period of record. Runoff for the period 1952 to 1982 is significantly greater than for the previous 30 years, and this in spite of a major diversion of flow out of the Fraser drainage (see below).

The lovermost 20,000 km^2 of the Fraser drainage area is subject to very intense autumn and early winter rainstorms due to large-scale frontal disturbances moving eastvard from the Pacific and rising over the Coast and Cascade Mountains. The storm of December 26, 1980 is a good example of this situation. At Hope, flows reached 4210 m^3/s on December 27, 1980, well below the annual peak of 6170 m^3/s of June 22nd. The drainage area increase from Hope to Mission amounts to only 5 percent.

The extent of the tidal reach of the Fraser varies with flow. At low flows it reaches to Sumas Mountain at km 95, but with Hope flows exceeding 5000 m^3/s tidal effects at Mission become very small. Flows reverse at Port Mann until the flow at Hope exceeds 4000 m^3/s (Ages and Woollard, 1978). Salt water from the Straight of Georgia can intrude some distance into the Fraser estuary, depending on flow and tide range. With lov Hope flows and large tides the salt wedge may reach New Westminster (km 35), but under freshet conditions it rarely extends beyond the Steveston Bend, km 10 (Beak, 1981).

Morphologically the lower Fraser can be divided into three distinct reaches. From Hope to Sumas Mountain the river is a vandering, split and unstable gravel-bed channel, frequently confined by bedrock spurs and by rip-rap-protected embankments. Confinement decreases below Hope as the valley widens. At km 95 there is an abrupt transition to a single, sinuous channel with a sand bed, frequently confined by pleistocene uplands. The delta reach starts at New Westminster, where the river splits into three distributaries.

The Fraser River has large commercial and recreational fish resources, primarily based on the five species of Pacific Salmon. Almost the entire main stem and most significant tributaries are utilized by salmon and this is the primary reason why the river remains essentially unregulated.

Only two tributaries of the Fraser River above Hope are significantly affected by regulation. The Nechako River above Kenney Dam would contribute some 8.5 percent to the flows at Hope (See Table 1.1). Of this, some 108 m^3/s or 4.6 percent of the Hope flows are diverted out of the Fraser drainage and 91.3 m^3/s or 3.9 percent are returned to the Fraser in a regulated manner, but a further 50 m^3/s may be diverted within the next 5 to 10 years. regulation of the Bridge River affects 4.3 percent of the Hope flows. Several tributaries to the tidal reach below Mission, the Stave, Alouette and Coquitlam Rivers are also regulated (Beak, 1981).

Over 1 million people live within a few kilometres of the lower Fraser River and the lowermost 37 km are navigable for oceangoing vessels. The remainder of the study reach is also navigable but is primarily used for towing logs, barging forest products, gravel and quarried rock, fishing and pleasure. Maintenance of the navigation channel is an ongoing problem. Below Port Mann, annual dredging is required. Several million cubic metres of sand are moved each year. The gravel-bed channel above Sumas Mountain also requires some maintenance in order to remain navigable.

The lower Fraser has a floodplain of some 82,000 ha, most of which is developed and protected from flooding by an extensive system of dikes, drainage canals and pump stations. The large freshet of 1948 flooded some 25,000 ha of developed land (Fraser River Joint Advisory Board, 1976).

KELLERHALS, R., ABRAHAMS, A.D. and VON GAZA, H.
1974: Possibilities for Using Suspended Sediment Rating Curves in the Canadian Sediment Survey Program.

ABSTRACT

Sediment rating equations for predicting mean daily suspended sediment concentration and load from the corresponding water discharge have been developed for five river sites in Alberta and in western Saskatchewan for which four to nine years of daily suspended sediment data are available. The technique used to fit rating equations to the data is stepwise multiple linear regression which is applied to log-transformed data. At most sites only mean daily discharge (Q) makes a significant contribution towards explaining mean daily concentration (C), and the contributions of discharge-related variables, such as "rate of change of discharge" or "time from spring rise" are generally negligible. The residuals of the regression are serially correlated to such a degree that the significance tests normally applied to regressions are meaningless. Plots of the residuals show that the rating equations give poor predictions of C, both during the spring rise in Q and whenever major rainstorms occur on the plains portion of the river basins. A preliminary attempt to improve prediction during major rainstorms by including regionally averaged precipitation into the rating equations was unsuccessful. By themselves, rating equations or curves do not give a satisfactory representation of suspended sediment data, because they fail to represent properly the expected distribution of C. Rating equations based on log-transformed daily data also tend to underestimate long-term sediment yields. Monthly and yearly rating curves can, however, be used for this purpose. A considerable number of other studies concerning rating curves are reviewed and the findings of the present study are shown to be in general agreement.

The objectives of the Sediment Survey program are stated in a form which differs somewhat from the official published version, but which is essentially equivalent. The degree to which the present survey program meets these objectives is then discussed and some suggestions are made on how a survey program based on the extensive use of rating equations could permit a closer approach to the objectives.

LAPOINTE, F.
1987: Evaluation de Rendement de Pompes Compatibles a L'Echantillonneur Automatique PWS.

SUMMARY

This report presents the results of hydraulic test carried out to establish the (head of water)-(discharge) curves for three pump models: Warren Rupp SPA1/2E, Jaccuzi BS4 and Hydromatic SP 50 MH. These pumps were selected by taking into account their compatibility with the automatic suspended sediment sampler, PWS. To complete the evaluation of these pumps, the interpretation of the results were based on constraints on the pumps resulting from the installation characteristics of the PWS (1). The constraints on the pumps are the flow resistance of the hydraulic system of the PWS and the static head between the water level and the manifold system of the sampler.

The results show that the Jaccuzi BS4 is the superior pump because it supplies the most discharge to the BWS. However, for a station that does not have an alternating current (AC) power supply, the Warren-Rupp (a DC pump) is the best choice. The Hydromatic pump SP 50 HM, is not recommended for use with the PWS because the discharge above. The results of laboratory test indicate the SP 50's performance is lower than the company's specifications.

The results also indicate that the PWS must use a sampling nozzle equal to or lower than 13 mm diameter. This will permit the pump to operate at a greater static head between the water level in the stream and the manifold system of the sampler, and ensure an adequate sampling velocity.

SOMMAIRE

Ce rapport présente les résultats d'essais hydrauliques, pour l'établissement de courbes de rendement, effectués sur trois modèles de pompes: Warren-Rupp SPA1/2E, Jaccuzi BS4 et Hydromatiques SP 50 MH. Le choix de ces pompes a été déterminé à partir de leur compatibilité avec l'échantillonneur automatique des sédiments en suspension, PWS(1). Pour compléter l'évaluation de ces pompes, l'interprétation des courbes de rendement a été basée sur les contraintes de charge imposées aux pompes résultant des caractéristiques d'installation du PWS(1). Les contraintes de charge sont la résistance à l'écoulement du système hydraulique du PWS et la charge statique entre le système d'embouteillage et le niveau d'eau de la rivière.

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1 Etude du comportement hydraulique de l'échantillonneur automatique, PWS, Lapointe F, Environment Canada.

Les résultats démontrent que la pompe Jaccuzi BS4 est celle qui offre le plus de débit. Toutefois pour des stations n'ayant pas de courant alternatif, l'utilisation de la pompe Warren-Rupp est le meilleur choix. La pompe Hydromatic SM 50 MH n'est pas recommandée pour le PWS car la capacité de cette pompe diminue rapidement sous les contraintes des charges. Les résultats obtenus en laboratoire ont été en-decà des spécifications présentées par la compagnie.

Ce rapport démontre, de plus, que les becs d'échantillonnage ne devraient pas dépasser 13 mm de diamètre pour permettre des vitesses de prélèvement adéquates afin d'assurer un échantillonnage de qualité et pour maximiser la hauteur statique disponible entre le système d'embouteillage du PWS et le niveau d'eau de la rivière.

LAPOINTE, F.

1987: MÉTHODES D'ÉCHANTILLONNAGE DES SÉDIMENT EN SUSPENSION - VARIABILITÉ ET CORRÉLATION.

SUMMARY

Water Survey of Canada makes use of automatic sampling systems for collecting suspended sediment data. The use of these systems permits better data coverage at stations and enables expanding the network at costs lower than for traditional methods and at sites with difficult access. In order to interpret and analyse the data from these new systems, it is necessary to have an in-depth understanding of the behavior of the factors causing the variability within each sampling method and amongst several sampling methods.

Intensive sampling of suspended sediment concentrations was carried out during the period from 23 March to 2 April, 1985 at the hydrometric station "BIG OTTER CREEK NEAR CALTON", 02GC026, in Ontario. The percentage of sand in suspension was particularly high. Sampling had been initiated in order to establish the variability in sampling methods and the correlations between them. The sampling methods studied were:

- five vertical sampling by the depth integrating method;
- single (control) vertical sampling by the depth integrating method;
- manual sampling at a point;
- automatic sampling at a point.

Simple and statified statistical sampling models, graphical interpretation and field observations were used in the analysis.

The study permits some quantitative demonstration of the differences amongst sampling methods and the types of samplers used for Canadian sampling sites. It has also provided an evaluation of the efficiency of the automatic PWS samplers. The precision of the sampling methods are notably similar and in the order of five percent for suspended sediments of the silt and clay sizes. Differences amongst the sampling types and methods have been observed to be more noticeable for sand size suspended sediments. Precisions from ten to twenty percent were observed. The precision of the manual point sampling is less sensitive to the presence of sand in suspension. Although single depth integrations are less precise then point integrations, the integrated sampling at five verticals estimates the mean concentration to a fairly good degree of precision. The confidence interval to 95% of the mean concentration was in the order of three percent for samples containing nearly fifty percent sand. The automatic PWS sampler was the instrument where the variability was the most sensitive to sand in suspension. It was also with this sampler that the largest quantity of outlier data were observed.

Results demonstrate that correlation between sampling methods is difficult to establish as both individual method precision and changing relationships between methods over the duration of a "sediment event" influence the correlation. After removing the effects of sampling precision, the linear relationship defining the relationship between the

manual methods has a standard error of estimate of six percent. The standard error was twelve percent for the correlations between the PWS automatic sampler and the manual methods.

This report allowed the establishment of the efficiency of the PWS automatic sampler. Although the use of this method increases the uncertainty of the data, the data are for the greatest part representative of the true behavior of the sediment in suspension. The principal weaknesses of this method are that both the data analysis and the correlation are actually difficult to establish. These weaknesses are evident for all automatic samplers. Other studies on automatic samplers are necessary before integrating this method into the Canadian network. The development of a data analysis program and evaluating the cost-benefit ratio of such a program are examples of studies to undertake.

SOMMAIRE

La Division des relevés hydrologiques du Canada fait des tentatives d'implantation de systèmes automatisés de prise de données concernant les sédiments en suspension. L'utilisation de ces systèmes permettrait d'améliorer la couverture de données aux stations et d'étendre le réseau, à des coûts inférieurs aux méthodes traditionnelles et à des sites difficilement accessibles. Pour interpréter et analyser les données de ces nouveaux systèmes, une compréhension approfondie des comportements des facteurs causant les variabilités entre les prélèvements et entre les méthodes de prélèvement est nécessaire.

Des prélèvements intensifs des concentrations de sédiment en suspension ont été effectués durant la période du 23 mars au 2 avril 1985 à la station hydrométrique BIG OTTER CREEK NEAR CALTON, 02GC026, en Ontario. Le poucentage de sable en suspension a été particulièrement élevé. Des prélèvements ont été effectués dans le but d'établir la variabilité des méthodes d'échantillonnage et leurs corrélations entre-elles. Les méthodes d'échantillonnage à l'étude ont été:

- l'échantillonnage intégré sur cinq verticales en fonction de la profondeur;
- l'échantillonnage d'une verticale contrôle en fonction de la profondeur;
- l'échantillonnage manuel en un point;
- l'échantillonnage automatique en un point.

Ce rapport démontre que la corrélation entre les méthodes d'échantillonnage est difficile à établir car non seulement les méthodes comparées ont une variabilité importante ce qui augmente l'incertitude à établir la relation mais la relation change au cours des événements de concentrations. Ainsi, indépendamment de la variabilité des prélèvements, en utilisant la relation linéaire pour définir le comportement entre les méthodes manuelles, l'erreur standard sur l'estimation a été de 6 pour cent. L'erreur standard était de douze pour cent pour les corrélations entre l'échantillonnage automatique, PWS, et les méthodes manuelles.

Ce rapport a permis d'établir le degrés d'efficacité de l'échantillonneur automatique PWS. Bien que l'utilisation de cette méthode diminue le degré de certitude des données, les données sont pour la grande majorité représentatives du comportement réel des sédiments en suspension. Les principales faiblesses de cette méthode sont que l'analyse des données et que l'établissement de la corrélation sont actuellement difficiles à établir. Ces faiblesses sont communes toutefois à tous les échantillonneurs automatisés. D'autres études sur l'échantillonnage automatique sont nécessaires avant d'intégrer cette méthode au réseau canadien. Le développement d'un programme sur l'analyse de données ainsi que l'évaluation des avantages-coûts de son utilisation sont quelques exemples des études à entreprendre.

Des modèles statistiques d'échantillonnage simple et stratifié ont été employés dans l'analyse ainsi que l'interprétation graphique et les observations sur le terrain.

L'étude a permis de démontrer quantitativement les différences entre les méthodes d'échantillonnage et les types d'échantillonneur selon le contexte canadien du site de prélèvement. Elle a permis aussi d'établir le degrée d'efficacité de l'échantillonnage automatique PWS. La variabilité des méthodes d'échantillonnage est sensiblement semblable et de l'ordre de cinq pour cent pour les sédiments en suspension de la granulométrie du limon et de l'argile. La différencienciation entre les types d'échantillonnage et les méthodes s'observe de manière plus marquée pour les sédiments en suspension de la granulométrie du sable. Des variabilités de dix à trente pour cent ont été observées.
L'échantillonnage manuel ponctuel est la méthode de prélèvement dont la variabilité est le moins sensible à la présence des sables en suspension. Bien que la variabilité soit plus grande pour les prélèvements des concentrations en fonction de la profondeur, l'échantillonnage intégré sur cinq verticales estime la concentration moyenne à une assez bonne précision. La précision de la concentration moyenne était de l'ordre de trois pour cent (intervalle de confiance: 95 %) pour des échantillons contenant près de cinquante pour cent de sable. L'échantillonneur automatique PWS a été l'instrument dont la variabilité a été la plus sensible au sable en suspension. Il a été aussi celui dont le plus grand nombre de données aberrantes a été observé.

LAPOINTE, F.
1986: Étude du comportement hydraulique de l'échantillonneur automatique PWS.

SUMMARY

The evaluation of the precision and the improvement of the automatic suspended sediment sampler, PWS, are two important projects of the Sediment Survey Section.

The principal factors influencing the precision of the PWS are: the shape and the size of opening (diameter of the intake), the intake velocity and the capacity of the hydraulic system. Ironically these factors concerning the PWS have never been thoroughly studied. Taking this into consideration, several tests were conducted at the NWRI Laboratory (Burlington) in August, 1984.

This report provides an insight into the different tests and their results. Comments and possible applications of the results for future installations are also presented. From the interpretation of the test results, the following recommendations are presented for improving the hydraulic aspects of the PWS:

1) Eliminate the Water Motor from the Control Unit of the PWS;

2) Improve the bottling system by reducing the flow resistance in the following manner:

   - eliminate the roughness caused by the protrusion of secondary pipes in the collector system,

   - eliminate the constriction of the soft tubing used as elbows for the manifold;

3) Reduce the diameter of the sampler inflow by adapting a nozzle. Prototype nozzles are suggested in Section 2.7, however, further study should be carried out to improve the nozzle design.

4) Outflow from the manifold should be released to an open system (i.e. released to atmospheric pressure).

This is one step in a series of investigations about the PWS. Additional investigations must be carried out to determine the correlation between the PWS results and the single vertical sampling results. The design of the PWS must be improved in order to increase sampling efficiency and to facilitate instrument operation.

LAPOINTE, F.

1985: Étude de la variabilités des méthodes d'échantillonnage des sédiments en suspension pour des concentrations inférieures à 50 mg/L.

INTRODUCTION

Cette étude a été faite à partir des recommandations du rapport "Etude de la Représentativité de l'Echantillonneur Automatique PWS Basée sur les Données Existantes". Une carence de renseignements concernant la variabilité des méthodes d'échantillonnage avait été constatée. Dans le but d'acquérir ces renseignements, un programme de relevés a été entrepris en Alberta, au printemps 1983. Initialement, l'étude de deux rivières à granulométrie différente avait été envisagée. Malheureusement, les faibles concentrations rencontrées nous ont contraint à n'étudier qu'une seule station, HIGHWOOD RIVER NEAR THE MOUTH (05BL024) et de ne traiter que des concentrations inférieures à 50 mg/L.

LAPOINTE, F.
1983: Étude de la representativité de l'échantillonneur automatique PWS basée sur les données existantes.

INTRODUCTION

L'utilisation de l'échantillonnage automatique au Canada débute en 1970 avec l'acquisition des modèles américains US-PS67 et SIRCO. En 1972 nous commençons à se servir d'un échantillonneur canadien, le PWS. Depuis sa mise en opération, peu d'études ont été effectuées. Au total il y a eu un rapport sur des essais en laboratoire et deux rapports traitant de son comportement sur le terrain. Le rapport du laboratoire concluait que l'échantillonneur automatique donnait des résultats satisfaisants tandis que les deux autres rapports affirmaient le contraire. Sur le terrain lorsque les conditions étaient mauvaises, les concentrations obtenues par le PWS montraient des variations élevées pour des échantillons pris successivement.

LEWIS, C.P. and ASSOCIATES.
1987: Mackenzie Delta Sedimentary Environments and Processors: Issues and Recommendations.

SUMMARY

The modern Mackenzie Delta is an active sediment surface which supports a large and vulnerable arctic/sub-arctic ecosystem that is very important to the traditional lifestyle and economy of the people of the region. The delta, including its ecosystem, has been created by and remains highly dependent on the Mackenzie River sediment that is disbursed through it by the distributary channel network. In addition, recent estimates suggest that the Mackenzie supplies about 96 percent of the sediment delivered annually to the Beaufort Sea. The nature of delta sedimentary environments, including the processes associated with them, therefore, will have major significance for engineering design on the delta surface. The danger exists, as well, that any development upstream from or on the delta plain that could affect sediment movement within or through the delta, could also significantly impact many other ecosystem components, both on the delta itself and throughout the bordering Beaufort Sea.

In spite of development pressures over the past 15 years, the data base relevant to all aspects of sediment movement and storage within the Mackenzie Delta remains largely inadequate for practical application. Several significant but limited studies were undertaken in the 1960's by Mackay (1963) and others (e.g. Gill, 1976; Smith, 1973) in the 1970's in association with proposals for a Mackenzie Valley gas pipeline and energy corridor. Since then, considerable work has been undertaken offshore but the only major onshore initiative has been the examination of distributary channel processes by Lapointe (1984). B.C. Hydro proposed an extensive investigation of "Mackenzie Delta Sedimentation" as part of its Liard River Hydroelectric Development studies but the project was cancelled while still in its initial stages.

The recommendations for future study which follow recognize the general limitations in our knowledge about sedimentary environments and the processes on the Mackenzie Delta but are intended to focus work on the topics of most immediate practical concern and to suggest approaches to those topics which will provide the greatest benefit for the least cost. The recommended studies are not presented in any order of priority. That will depend upon the individual perspectives of potential users and of the agencies that must fund the work.

LINTON, L.R., HAMILTON, H.R., FUGLEM, M.
1988: Similarities in Estimates of Suspended Sediment between Water Quality Branch and Water Resources Branch for Sites in the Saskatchewan River Basin.

OBJECTIVES

Suspended-sediment data are collected by two Branches of Inland Waters Directorate, Environment Canada. The objectives of the work reported here were to evaluate the compatability of the suspended sediment data (SS) of Water Resources Branch (WRB) with the nonfilterable-residue data (NFR) of the Water Quality Branch (WQB). The validity of pooling the data when necessary was assessed. The study worked with historical data collected from the Saskatchewan River Basin.

McILHINNEY, J.L.
1988: Station Review Plot Package.

ABSTRACT

The following pages contain:

1) general information on acquiring plots and listings;
2) specific information you need to know about a station and selected plots before requesting plots;
3) a blank Plot Request form;
4) sample plots and listings.

Before requesting plots you should have an idea of the history of the station and which plots would be beneficial. Each plot costs between $2.00 and $10.00 while a total set of plots for one station would cost between $100.00 and $200.00 (before rebate, if applicable). Because of the costs for obtaining the plots, the amount of requests for plots and the limitations of our budget, it has been decided that small requests for plots will be handled through our Section, but larger requests should be done by your own Region. This can be done by filling out a form for an interactive account from Computer Services Center, E.M.R. Once this is complete and you have an account, you can run your own plot requests from your office using DATAPAC. Most of the plots can be requested by:

1) Enter "LOGIN,username,password." Press <RETURN> key.
2) Enter "ATTACH,X,PLOT,ID=PACKAGE1,PW=SSS,MR=1.". Press <RETURN> key.
3) Enter "IGET,A=START/X.". Press <RETURN> key.
4) Enter "BEGIN,START,A.". Press <RETURN> key.

Then follow the user friendly instructions to obtain the desired plots.

If you have any questions please call Joseph McIlhinney 819-997-1185.

McILHINNEY, J.L.
1987: Hydrographic Data Reduction and Analysis System Manual - HYDRA.

BACKGROUND

What is HYDRA?

HYDRA stands for Hydrographic Data Reduction and Analysis system, developed for the Sediment Survey Section, Water Survey of Canada Division.

Its name implies its function, that is, to compute or reduce large volumes of hydrographic data collected from the field into a meaningful form from which pertinent analyses can be made.

HYDRA consists of a series of steps or stages in what is termed the HYDRA "process". These stages must be performed in a specific order. For example, the data which is obtained as the resultant from one stage, is the data to be input to the next stage.

For each stage of HYDRA, there are computer programs which perform the actual calculations on the data which is input. The HYDRA stages or 'PROCS' (from the word procedures) simply access which data to use, which program(s) to use on that data, and where to store the output data. Any errors detected by the computer in the data (or lack of data) will cause the program to "bomb", and an error message will appear on the computer printout to give an indication as to where the problem lies. Similarly, the PROC itself has built-in controls which ensure that the proper data has been inputted, inputted in the correct sequence, and stored or catalogued in its proper place for future use.

Throughout the process of HYDRA, a 377K memory computer, called the CYBER 730, is used. The computer is located at, and operated by, the Computer Science Centre (CSC), Department of Energy, Mines and Resources, Ottawa (613-996-0296).

McILHINNEY, J.L. and CASHMAN, M.A.
1984: ODEN Curve Automation Study.

INTRODUCTION

The bottom withdrawal tube analysis (BWTA) method is one of the standard methods used to analyze the particle size distribution of suspended sediment samples. This method is being used in the four Water Resource branch Sediment Laboratories in Canada and has been used in several Federal Sediment Laboratories in the United States for many years. The BWTA method of particle size analysis is based on the theory of a uniformly dispersed sedimentation system, which was first presented by Oden (1916). The method was later generalized by Fisher and Oden (1923), and summarized with discussions by Oden (1925) and Krubein and Pettijohn (1938).

Direct application of the theory for a given sample of sediment would require uniform particle size distribution, but this distribution in general is not available. Therefore, the graphical approach of the BWTA method is more generally adopted. The application of Oden's theory in the BWTA method results in an accumulation curve, the so-called Oden curve. This curve has time as the abscissa axis and percentage by weight of the total material settled out in a fixed column of 100 cm as the ordinate. A tangent is drawn from the Oden curve at a specific time, determined by a selected particle size at a given temperature, to intercept on the ordinate. This point of interception represents the corresponding "percent finer" of the selected particle. However, the range of time covering the settlement of the sediment is so large and the measured points are so unevenly distributed along the time scale that it is difficult to draw a continuous curve with an acceptable accuracy on rectangular coordinate paper. To overcome this difficulty, the curve is broken up into segments with overlapping between two adjacent segments (Report No. 7, The Inter-Agency Committee on Water, 1943). The average of two tangents is taken when a selected particle size is located in the end portions of two overlapping time segments.

The division of a continuous Oden curve into segments in some cases, has been found to cause discrepancies with the correct curve. For example, in the manual computations the larger scale makes it particularly difficult to accurately draw the right portions of curve C and curve D (Report No. 10, The Inter-Agency Committee on Water, 1953).

Automating the BWTA procedure would save a considerable amount of time over the manual computations and procedures. Also, it would provide better quality control as results would always be the same for a particular set of data. Due to human interpretation it is possible to get different results from the same set of data computed manually.

McLEAN, D.G.
1985: Lower Fraser River Survey 1984: Agassiz-Rosedale Bridge to Mission.

ABSTRACT

During the summer of 1984 hydrographic surveys were carried out over the 46.5 km of the Lower Fraser River between Mission and the Agassiz-Rosedale Bridge. An Environment Canada crew with the automated HYDAC survey system collected over 400 cross sections along 38.5 km of main channel. UBC crews surveyed 136 cross sections over 10 km of the main channel and 18 km of side channels using conventional hydrographic surveying techniques. Approximately one man-year of effort went into the field work. This work represents the first comprehensive survey in this reach since 1952.

McLEAN, D.G. and CHURCH, M.
1986: A Re-Examination of Sediment Transport Observations in the Lower Fraser River.

INTRODUCTION

The main purpose of this report is to present estimates of the annual bedload and suspended load transport rates at Agassiz and Mission. As part of this study, a relatively complete review of the available sediment transport observations was carried out. Particular attention is given to predicting the size distribution of the load and to the problem of distinguishing the wash load and bed material load at each station. The reliability of the available measurements and the precision of the annual load estimates has also been assessed. Some aspects of this work have been published previously (McLean and Tassone, 1985; Mannerström and McLean, 1985).

The first sediment transport measurements on the Fraser River were collected by Johnston (1921) at New Westminster. Later on, a systematic programme of measurements was carried out between 1950 and 1952 at Hope (Kidd, 1953). These data were used by Mathews and Shepard (1962) to estimate the long-term sedimentation rate at the delta. In 1965 Water Survey of Canada began a comprehensive programme to measure the suspended load and bed load at several locations along the main stem and on some tributaries. Since this time bed load and suspended load have been measured periodically at Port Mann, Mission and Agassiz (Figure 1). Only suspended load data have been collected at Hope. Some early results from these measurements were analyzed by Tywoniuk (1972) and by Pretious (1972). More recently the data have been revieved by Western Canada Hydraulics Laboratories Ltd. (1978) and an overview of the programme was prepared by Kellerhals (1984). However, for the most part, the data have received very little systematic or critical analysis.

McLEAN, D.G. and MANNERSTROM, M.C.
1985: History of Channel Instability Lower Fraser River: Hope to Mission.

ABSTRACT

The history of lateral channel instability along the lower Fraser River between Mission and Laidlaw is described. Channel changes over the last century have been documented by preparing a series of large scale channel shift maps. Some of the factors governing past channel instabilities are described. Vertical channel changes were studied by analyzing available data from hydrometric stations and from repeat channel surveys.

NORTHWEST HYDRAULIC CONSULTANTS LTD.
1988: Assessment of Sediment Effects, Churchill River Diversion, Manitoba, Phase II Report.

ABSTRACT

This report constitutes Phase II of a two-part study to assess sediment effects along the Churchill River Diversion and related waterways in northern Manitoba and to recommend further studies required for monitoring and assessment. The Phase I report, issued in May 1987 and revised in October 1987, discussed potential sediment effects, sources and sinks, and previously reported sediment budgets, and reported limited additional analysis of available sediment data.

The Phase II report considers additional technical information on the effects of uncontaminated sediment on aquatic resources and on the implications of contaminant attachment to sediment, and summarizes the indications of a limited examination of satellite images with regard to spatial and temporal variations in sediment content along the Churchill River Diversion. Cases for and against further sediment field studies are revieved and recommendations are made for a limited program to satisfy in part the requirements of the Northern Flood Agreement and in part general scientific and national objectives. An assessment is made of sediment effects in relation to specific northerm communities.

NORTHWEST HYDRAULIC CONSULTANTS LTD.

1986: The Use and Publication of Hydraulic and Morphologic Data for Canadian Rivers.

ABSTRACT

The files of the several thousand Water Survey of Canada hydrometric stations in Canada contain hydraulic and morphologic information that is largely unprocessed for publication. An assessment of the potential value of making this information readily available in a published form was the primary purpose of the study summarized herein.

The long development of ideas on the systematic compilation of river data has principally been for scientific purposes. Adaption of these ideas to engineering and environmental studies is outlined. Several case histories are presented in which a Water Survey of Canada gauge was located in close proximity to sites where river hydraulic and morphologic data were collected for specific engineering studies.

A review is made of what baseline data are typically available at a gauge site, and what hydraulic and morphologic information could be extracted and published after perhaps some additional field work. Recommendations are made with respect to how alternative levels of publication effort could be pursued.

RÉSUMÉ

Les fichiers des milliers de stations hydrométriques de la Division des relevés hydrologiques du Canada contiennent des renseignements en matière d'hydraulique et de morphologie qui sont en grande partie non traités en vue d'une publication. L'étude résumée dans ce document avait principalement pour but d'évaluer dans quelle mesure il serait utile de faciliter l'accès à ces renseignements en les publiant.

La longue évolution des notions inhérentes à la compilation systématique des données relatives aux cours d'eau a surtout visé des buts scientifiques. On expose à grands traits l'adaptation de ces notions à des études de génie et à des études environnementales. On présente plusieurs cas de jauges de la Division des relevés hydrologiques du Canada situées à proximité d'emplacements où des données en matière d'hydraulique et de morphologie étaient collectées en vue d'études spécifiques de génie.

On examine quelles sont les données de base typiquement disponibles à un emplacement de jaugeage et quels renseignements en matière d'hydraulique et de morphologie pourraient être extraits et publiés après, peut-être, exécution de quelques travaux supplémentaires sur le terrain. On formule des recommandations sur la manière de mettre en branle d'autres formes d'activités reliées à la publication.

NORTHWEST HYDRAULIC CONSULTANTS LTD.
1986: Sediment Station Analysis: Saskatchewan River at the Pas, 05KJ001.

ABSTRACT

This is one in a series of sediment station analysis reports issued by Water Resources Branch, Environment Canada. It presents a summary and analysis of the 1954 to 1984 sediment record of the Saskatchewan River at The Pas. The data and analysis are interpreted in terms of upstream conditions and the changes that have occurred over the record period.

Hydroelectric, storage and irrigation developments in the basin during the record period have altered the flow regime and created sediment sinks. These developments include the construction of Gardiner Dam on the South Saskatchewan River and of Squaw Rapids Dam on the Saskatchewan River, both dur..ng the nineteen-sixties, as well as increasing irrigation withdravals from the South Saskatchewan system. Prior to the Squaw Rapids development and creation of Tobin Lake Reservoir in 1963, the Saskatchevan Delta - Cumberland Lake complex was an area of net sediment deposition. It appears that since 1963 the situation has reversed and that the delta is now an area of net erosion.

It is considered that the available data at The Pas sufficiently describe the present sediment regime, and that the data collection program could well be suspended for a period and then reinstated to check for consistency. This recommendation should, however be discussed with Water Quality Branch. A short-term program is suggested to determine sediment loads in various parts of the delta complex in the Cumberland Lake area. Comments are also made about the Prince Albert station.

RÉSUMÉ

Il s'agit d'un rapport d'analyse de station de levées sédimentaires dans une série que publie la Direction des ressources en eau d'Environnement Canada. Il renferme un résumé et une analyse des relevés sur les sédiments de la rivière Saskatchevan à The Pas de 1954 à 1984. Les données et l'analyze sont interprétées en fonction des conditions en amont et des changements qui se sont opérés au cours de la période visées par les relevés.

Les travaux d'aménagement hydroélectrique, de constitution de réserves d'eau et d'irrigation dans le bassin au cours de la période visée par les relevés ont modifié le régime d'écoulement et ont créé des bassins de sédiments. Parmi les aménagements, il y a eu la construction du barrage Gardiner sur la rivière Saskatchevan-Sud et du barrage Squav Rapids sur la rivière Saskatchevan-Sud - dans les deux cas, au cours des années 60 - et il y a aussi eu l'augmentation des prélèvements d'eau pour l'irrigation à même le bassin de la Saskatchewan-Sud. Avant la construction du barrage Squav Rapids et la création du réservoir Tobin, en 1963, le complexe du delta de la riviéere Saskatchevan et du lac

Cumberland était un endroit où il y avait dépôt net de sédiments tandis que tout porte maintenant à croire que depuis 1963, c'est l'inverse que s'est produit et le delta est maintenant un endroit où il y a perte nette de sédiments.

On estime que les données connues à The Pas décrivent avec suffisamment de précision le régime sédimentaire actuel et que le programme de collecte des données pourrait être suspendu pendant un certain temps et repris par la suite afin de vérifier si les données sont constantes. Il faut cependant que cette recommendation soit discutée avec la Direction de la qualité des eaux; on suggère qu'il devrait y avoir un programme à court terme afin de déterminer la charge sédimentaire à divers endroits du complexe du delta dans le secteur du lac Cumberland. Il y a également des observations sur la station de Prince-Albert.

NORTHWEST HYDRAULIC CONSULTANT LTD.
1985: Assessment of Sediment Issues and Survey Program in the Prairie Provinces.

INTRODUCTION

The study is one of a series commissioned in 1984 by the Sediment Survey Section of Water Resources Branch, Environment Canada. It was designed to provide a better understanding of the role and importance of streamborne sediment in the Prairie Provinces and to make recommendations for the future direction of the Sediment Survey program.

PENNER, F., YUZYK, T.R., OSHOWAY, R.
1987: A Compilation of Manitoba Sediment Data to 1985.

ABSTRACT

This report is a compilation of all the suspended sediment and bed material data that have been collected in Manitoba by the Manitoba Water Resources Branch and Water Survey of Canada. There is a total of 63 sites in the province where sediment data have been collected. The data are presented in various formats, with a possible nine figures and three tables used to depict the information for each site. Data collected by other agencies are also referenced. The information from this compilation will be used to help evaluate the sediment program in Manitoba.

POL, R.A.
1988: Interpretation of Sediment Data, 1967-1985, Annapolis River Nova Scotia.

ABSTRACT

Sediment data have been collected at the hydrometric gauging station site, Annapolis River at Wilmot, from 1967 to the present as part of the ongoing Water Resources Branch National Sediment Surveys Program. This report deals primarily with suspended sediment data collected during the period 1968 to 1985, inclusive, and presents the collected data in various tabular, graphical and statistical ways. It also contains a basin description and a section on land use and river sediments. The suspended sediment program, operated by the Water Survey of Canada Division, is evaluated and recommendations are presented. This material is intended for Federal/Provincial coordinators of water agreements, Water Survey of Canada staff and users of sediment data.

The analyses and interpretations of the sediment data are for the purpose of assessing if sufficient data exist for load determinations. The interpretation of the suspended sediment data set showed that our knowledge of mean characteristics of the sediment regime can improve only slightly; therefore, it is being recommended that the sediment station be discontinued and that the resources be reallocated to obtain sediment data in areas where monitoring has not been done.

RÉSUMÉ

Des données sédimentologiques ont été prélevées à la station de relevés hydrométriques de la rivière Annapolis à Wilmot à partir de 1967 jusqu'à présent. Ces prélèvements font partie du Programme national d'échantillonnage sédimentologique de la Direction des ressources en eau.

Ce rapport traite principalement de données sur les sédiments en suspension rassemblées durant la période de 1968 à 1985 et les présente sous formes de tableaux, de graphiques et de statistiques. Le rapport comprend aussi une description du bassin, une section sur l'utilisation du terrain, ainsi qu'une secton sur les sédiments de rivière. Le rapport fait une évaluation du programme sur les sédiments en suspension de la Division des relevés hydrologiques du Canada et offre aussi des recommendations. Ce travail seral utile aux coordonateurs des ententes fédérales-provinciales sur l'eau, aux employés de la Division des relevés hydrologiques du Canada et aux usagers de données sédimentologiques.

Les analyses et les interprétations effectuées sur les données sédimentologiques ont permis d'évaluer la suffisance des données sur les sédiments en suspension pour en calculer le débit solide. Celles-ci ont montré que notre connaissance du régime sédimentologique en terme de production moyenne n'augmenterait pas sensiblement avec plus de données et qu'ainsi l'échantillonage peut être interrompu et les ressources réaffectées pour recueillir des données sédimentologiques dans des régions où l'échantillonage n'a pas encore été effectué.

POL, R.A.
1988: Interpretation of Sediment Data, 1972-1985, Wilmot River Prince Edward Island.

ABSTRACT

Sediment data have been collected at the hydrometric gauging station site, Wilmot River near Wilmot Valley, Prince Edward Island from 1972 to the present as part of the ongoing Water Resources Branch National Sediment Surveys Program. This report deals primarily with suspended sediment data collected during the period 1972 to 1985, inclusive, and presents the collected data in various tabular, graphical and statistical formats. It also contains a basin description and a section on land use and river sediments. The suspended sediment program, operated by the Water Survey of Canada Division, Water Resources Branch, is evaluated and recommendations are presented. This material is intended for the Federal/Provincial coordinators of the cost shared Water Quantity Surveys, Water Survey of Canada staff and users of sediment data.

The analyses and interpretations of the sediment data are for the purpose of assessing if sufficient data exist for load determinations. The interpretation of the suspended sediment data set showed that our knowledge of mean characteristics of the sediment regime can be improved only slightly by further sampling. The Wilmot River sediment station is one of two sediment stations in the most active agricultural zone of the province. The Wilmot gauge has more accurate sediment data relative to the other sediment gauge. Therefore, it is recommended that the detailed sediment sampling on the Wilmot River be continued for at least another five years.

RÉSUMÉ

Des données sur les sédiments ont été collectionnées à la station hydrométrique Wilmot River près de Wilmot Valley, Ile-du-Prince-Edouard à partir de 1972 jusqu'à présent comme composante du Programme national des relevés des sédiments de la Direction des ressources en eau. Ce rapport, qui s'occupe principalement des données sur les sédiments en suspension obtenues pour la période de 1972 à 1985 inclusivement, les présente sous divers formats tabulaires, graphiques et statistiques. Ce rapport contient aussi une description du bassin de même qu'une section sur l'utilisation des terres et les sédiments de rivière. Le programme de sédiments en suspension, opéré par la Division des relevés hydrologiques du Canada, Direction des ressources en eau, est évalué et des recommendations sont présentées. Ce matériel fut préparé pour les coordinateurs d'ententes féderales-provinciales à frais partagés sur les Relevés de la quantité des eaux, pour les employés de la Division des relevés hydrologiques du Canada et pour les utilisateurs des données sur les sédiments.

Les analyses et les interprétations des données de sédiment ont pour but d'évaluer s'il existe suffisamnent de données pour déterminer les débits solides. L'interprétation des données sur les sédiments en

suspension nous indique que nos connaisances en termes de caractéristiques moyennes du régime sédimentologique ne s'améliorerait que peu avec de l'échantillonage additionnel. La station de sédiment de Wilmot River est une des deux stations de sédiment dans la zone agricole la plus active de la province. Parce que la jauge de Wilmot River a des données de sédiment plus exactes relativement aux autres jauges de sédiment, il est recommandé que l'échantillonage intense sur la rivière Wilmot soit continué pour au moins cinq ans.

POL, R.A.
1987: Interpretation of Sediment Data, 1966-1984, Kennebecasis River, New Brunsvick.

ABSTRACT

Sediment data have been collected at the hydrometric gauging station site, Kennebecasis River at Apohaqui, from 1966 to the present as part of the ongoing Water Resources Branch National Sediment Surveys Program. This report deals primarily with suspended sediment data collected during the period 1967 to 1984, inclusive, and presents the collected data in various tabular, graphical and statistical vays. It also contains a basin description and a section on land use and river sediments. The suspended sediment program, operated by the recommendations are presented. This material is intended for Federal/Provincial co-ordinators of water agreements, Water Survey of Canada staff and users of sediment data.

The analyses and interpretations of the sediment data are the purpose of assessing if sufficient data exist for load determinations. The interpretation of the suspended sediment data set shoved that our knowledge of mean characteristics of the sediment regime can improve only slights; therefore, it is being recommended that the sediment station be discontinued.

RÉSUMÉ

Des données sédimentologiques ont été prélevées à la station de relevés hydrométriques de la rivière Kennebecasis à Apohaqui à partir de 1966 jusqu'à présent. Ces prélèvements font partie du Programme national d'échantillonnage sédimentologique de la Direction des ressources en eau.

Ce rapport traite principalement de données sur les sédiments en suspension collectionnées durant la période de 1967 à 1984 et les présente sous formes de tableaux, de graphiques et de statistique. Le rapport comprend aussi une description du basin, une section sur l'utilisation du terrain, ainsi qu'une section sur les sédiments de rivière. Le rapport fait une évaluation du programme sur les sédiments en suspension de la Division des relevés hydrologiques du Canada et offre aussi des recommendations. Ce travail sera utile aux coordonateurs des ententes fédérales-provinciales sur l'eau, aux employés de la Division des relevés hydrologiques du Canada et aux usagers de données sédimentologiques.

Les analyses et les interprétations effectuées sur les données sédimentologiques ont permis d'évaluer la suffisance des données sur les sédiments en suspension pour en calculer le débit solide. Celles-ci ont montré que notre connaissance du régime sédimentologiques en terme de production moyenne n'augmenterait pas sensiblement avec plus de données et qu'ainsi l'échantillonnage peut être discontinué.

SMITH, B.D.
1987: Sediment Data Analysis: Big Creek near Walsingham 02GC007.

ABSTRACT

Suspended sediment data were collected at the hydrometric gauging station site "Big Creek near Walsingham 02GC007" during the period 1966 to 1983 (station still active 1984-1986). This report documents data in various tabular, graphical and statistical forms. Descriptions of the reach, bed material data and photographs of the site are also included. Further intensive sampling will not improve the understanding of the suspended sediment transport at this site and it is recommended that the station be discontinued.

Results indicate that the sampling program operated within the entire range of flows and events and during a period of increasing annual mean flows. Seasonality trends in both discharge and sediment were evident and were partially precipitation oriented. Agricultural practices seem to agree with the seasonality of results. However, definite periods of flow-concentration relationships occur, examples being the spring versus summer months. No large scale changes in bed material or suspended sediment particle size occurs although bar migration occurs to the extent it controls hydraulic changes in the channel.

Database results in addition to summarizing sediment transport characteristics of this flow regime, were used for recommendations on the station's operational status.

RÉSUMÉ

On a recueilli les données sur les sédiments en suspension à la station hydrométrique 02GC007 de Big Creek près de Walsingham entre 1966 et 1983 et la station fonctionne encore (1984-1986). Les données sont présentées dans le rapport sous diverses formes tabulaires, graphiques et statistiques. On fournit aussi la description du plan d'eau, les données sur le matériau de fond et des photographies de l'emplacement. On pense que l'on n'améliorera pas les connaissances sur le transport des sédiments en suspension à cet emplacement en poursuivant l'échantillonnage intensif et l'on recommande donc que la station soit fermée.

Les résultats indiquent qu'au cours du programme d'échantillonnage, on a observé l'éventail complet de l'écoulement et des phénomènes à étudier et ce, lors d'une période d'augmentation de l'écoulement annuel moyen. On montre l'évidence des tendances saisonnières du débit et des sédiments, qui sont partiellement liées aux précipitations. Il semble y avoir une relation entre les pratiques agricoles et le caractère saisonnier des résultats. Toutefois, certaines périodes donnent lieu à des rapports entre l'écoulement et la concentration des sédiments, par exemple les mois de printemps par opposition à ceux d'été. On ne remarque pas de grand changement quant aux dimensions des particules du matériau de fond et des sédiments en suspension, mais l'on note une migration de la

barre suffisante pour compenser les changements hydrauliques dans le chenal.

Les recommandations faites sur l'existence de la station se fondent sur les résultats de la base des données ainsi que sur le sommaire des caractéristiques du transport des sédiments pour le régime d'écoulement étudié.

SPITZER, M.O.
1987: Sediment Data Milk River Basin.

ABSTRACT

Sediment data were collected in the mid-seventies and the early eighties at seven gauging stations situated along the reach of the Milk River from above the western crossing of the International Boundary to immediately below its re-entry into the U.S.A. at its eastern crossing of the International Boundary. This report documents the available sediment information, presenting the data in various tabular and graphical formats.

In particular, for each gauging station, varying amounts of the following data are documented and discussed:

- descriptions of the gauging station sites (including air and ground photos)
- hydrometric details at the gauging stations sites
- suspended sediment data (concentration, load and particle size)
- bed material data
- dissolved solids data
- bed load data (only at the eastern crossing site)

The data are contained in individual appendices for each gauging station, while comparisons among the sites are contained within the main body of the report.

For the most part, sufficient data are available to make reasonable estimates of sediment loadings at various points along the Milk River reach, but these estimates must be based on procedures other than single line regression sediment discharge ratings.

RÉSUMÉ

Les données sur les sédiments ont été recueillies au milieu des années soixante-dix et au début des années quatre-vingt, dans sept stations de calibrage situées le long de la rive droite de Milk River, entre l'endroit où elle franchit la frontière internationale à l'ouest jusqu'immédiatement au dessous de l'endroit où elle rentre aux Etats-Unis en refranchissant la frontière à l'est. Le présent rapport fait état des renseignements disponibles sur les sédiments, en présentant les données dans différentes tables et graphiques.

En particulier, pour chaque station de calibrage, les données suivantes sont données et commentées en nombres variables:

- descriptions des emplacements des stations de calibrage (incluant des photos aériennes et terrestres);
- détails hydrométriques relevés aux emplacements des stations de calibrage;

- données sur les sédiments en suspension (concentration, densité et dimensions des particules);
- données sur les matériaux du lit;
- données sur les matériaux solides dissous;
- données sur la charge du l't (seulement à l'endroit où la rivière franchit la frontière à l'est).

Les données se trouvent dans des annexes propres à chaque station de calibrage, alors que les comparaisons entre les emplacements figurent dans le texte du rapport.

Dans l'ensemble, les données sont suffisantes pour faire des estaimations raisonnables sur les charges de sédiments à différents points de long de la rive droite de Milk River, mais ces estimations doivent se fonder sur des procédés différents des estimations des décharges de sédiments de regression en une seule ligne.

THOMPSON, M.P., JOE, H., CHURCH, M.
1988: Statistical Modelling of Sediment Concentration.

ABSTRACT

Estimates derived from a "rating curve" may be used to replace costly daily samples of sediment concentration in assessing sediment discharge. This technique relies on the consistency of the relationship between sediment concentration and water discharge to estimate long-term sediment loads.

In this study, a regression/time-series approach to modelling the relationship between sediment concentration and water discharge is developed. The model consists of a linear regression of the logarithm of sediment concentration on the logarithm of water discharge plus an autoregressive time-series of order one or two for the errors of the regression equation. The model is used to estimate the annual sediment load and its standard error. Correction factors for the bias resulting from the inverse transformation of the logarithm of sediment concentration are studied. The accuracy of the load estimates is checked by comparing them with figures published by Water Survey of Canada.

RÉSUMÉ

Les estimations faites à partir d'une courbe de tarage peuvent servir à remplacer l'échantillonnage coûteux de la concentration des sédiments qui est effectué quotidiennement afin de déterminer le débit solide. Cette technique repose sur l'uniformité du rapport qui existe entre la concentration des sédiments et le débit de l'eau pour estimer le transport des sédiments à long terme.

Dans le cadre de cette étude, l'auteur utilise la régression et la série chronologique dans le but de créer un modèle illustrant la relation entre la concentration des sédiments et le débit de l'eau. Le modèle comporte une régression linéaire du logarithme de la concentration des sédiments sur celui du débit de l'eau et inclut également une série chronologique de premier ou de deuxième ordre à propriété d'autorégression pour tenir compte des erreurs dans l'équation de régression. Le modèle sert à calculer appeoximativement le transport annuel des sédiments et son écart type. L'auteur étudie des facteurs pour corriger l'erreur systématique provenant de la transformation inverse du logarithme de la concentration des sédiments. Puis, il vérifie la justesse des estimations du transport en les comparant avec les données publiées par les relevés hydrologiques du Canada.

WASHBURN AND GILLIS ASSOCIATES LTD.
1985: Freshwater Sediment Data Collection and Use in the Atlantic Provinces.

EXECUTIVE SUMMARY

This report presents the findings of a study commissioned by the Water Resources Branch, Inland Waters Directorate of Environment Canada, into the collection and use of freshwater sediment data in the Atlantic Provinces. The primary objectives of the study were to acquire a better understanding of the key sediment issues in the Atlantic Provinces and to obtain a more complete recognition of the utility of Environment Canada's freshwater sediment data in addressing the present and future sediment issues of concern.

The study involved detailed discussions with a number of individuals in government, university, consulting and industry who were interested in freshwater sediment data. A standard questionnaire followed up the discussions with selected individuals. Information provided by these individuals was reviewed in detail, in order to identify the issues of concern in the region with respect to freshwater sediment. Recommendations for change to the Environment Canada sediment survey program were then developed in light of the issues of concern and the ability of the program to address those issues.

The existing Environment Canada sediment survey program in the Atlantic Provinces consists mainly of measurements and publication of suspended sediment concentration and loads at 17 hydrometric stations. There are six active stations in New Brunswick; four in Nova Scotia; three in Prince Edward Island; and four in Newfoundland (none of which are in Labrador). Since the sediment survey program was initiated, data have been collected from a number of stations with widely varying drainage basin sizes; some station data are short-term, while the longest period of record for any station is 20 years. The present database of sediment information does not appear to be targeted to any particular group of users in the Atlantic Provinces.

Various sectors throughout the working community of the region may have need for information on freshwater sediments. For the purposes of the present study, the key sectors adopted for categorization of users are government, university, consulting and industry. Although government involvement in freshwater sediment may include research and development of guidelines, governments in the Atlantic Provinces are also involved in regulations dealing with sediment. The federal Fisheries Act, and provincial water course alteration and environmental protection acts and regulations, may influence activities along rivers and streams and may thereby generate needs for sediment information.

Freshwater sediment issues in the Atlantic Provinces were identified through detailed discussions with a number of selected individuals. A list of potential contacts was first generated; then 106 persons were interviewed in detail and their responses recorded. Questionnaires were

then sent to 102 persons, and completed questionnaires were returned by 88. The majority of the 106 contact persons (59%) were government employees. Within the government sector, 62% were affiliated with environment departments. An intermediate or high level of interest in the topic of freshwater sediments was expressed by almost all of the 106 persons.

A variety of interesting points were illustrated through the analyses of the results of personal discussions and questionnaire responses. With respect to the avareness and use of freshwater sediment data, it was found that:

- 70% were avare of Environment Canada program;
- 20% in the government sector were not aware of the program;
- about 33% had used the Environment Canada suspended sediment data at some time;
- about 60% need sediment data to evaluate upstream and downstream changes due to a particular activity;
- only seven percent indicated that they needed data for the design of engineering projects.

With respect to the collection and analysis of data, some of the key points found through discussions and questionnaire responses were that:

- the present distribution of suspended sediment stations in the Atlantic Provinces is inadequate, though the reason that it is considered so is variable depending upon the individual;
- there is interest in having other data to complement the suspended sediment data, such as upstream land use information, particle size distribution, chemical constituents, organic fraction, and dissolved load;
- many individuals require sediment information to evaluate erosion from the land;
- there is need for improved communication between government departments regarding the sediment survey program.

Once the freshwater sediment issues of greatest concern in the Atlantic Provinces were targeted, the objective was to identify the sediment processes associated with those issues and the corresponding data requirements. With data requirements known, the present Environment Canada sediment survey program could be evaluated against the data needs, and recommendations for change could be developed.

In order to quantify data requirements, the report provides a series of tables corresponding to nine key areas of activities or impacts in the Atlantic Provinces. Each table identifies potential problems; processes associated with the problems; and data requirements to evaluate the appropriate processes. The nine key areas discussed are fisheries, forestry, agriculture, mining, construction activities, water supply, hydropower, recreation, and applied research.

Based on the problems and associated data requirements which are particular to the Atlantic Provinces, it appears that the Environment Canada sediment data program, in its present form, provides a limited

degree of support to data users. The primary reason is that many individuals require site-specific data for a limited period of time. Another important reason is that the transferability of sediment data (from one basin to another) is an open question to many data users. In addition, the Environment Canada data may be inadequate for those users who require additional data about sediment samples, such as organic fraction, metals content, or presence of contaminants.

It is noted, however, that despite the unknown "value" of the sediment data being collected at present, many individuals feel that sediment data are necessary for understanding the processes and the sediment regime of the region. This opinion was considered important, and it was reflected in the recommendations of the report.

The report provides a series of recommendations. Because the study had the objective of evaluating the Environment Canada sediment program from an outside perspective, the recommendations are broad-ranging, and do not necessarily follow the current program mandate. Recommendations are given in six sub-sections.

WASHBURN AND GILLIS ASSOCIATES LTD.
1986: Proceedings of Freshwater Sediment Issues Workshop, June 26, 1986, Charlottetown, P.E.I.

ABSTRACT

On June 26, 1986 a workshop on Freshwater Sediment Issues was held at the University of Prince Edward Island in Charlottetown. The workshop brought together individuals from the four Atlantic provinces who are dealing with problems of the source, transport, fate, and environmental effects of sediment in freshwater. Representatives from university, industry, consulting, provincial government, and the federal government took part in the intensive one-day workshop, which included 22 short presentations followed by four simultaneous working group sessions.

The workshop was jointly funded by the Environment Departments of the four Atlantic provinces and the Water Resources Branch of Environment Cana . The initiative of the Water Resources Branch was instrumental in mak g the workshop a reality.

The results of the workshop have been condensed into proceedings, which provide, first, the rationale for the workshop and its objectives; second, the proceedings themselves, given in a concise format; and third, a series of recommendations for new directions in sediment programs in the region. Recommendations are given which span the full range of sediment issues. The formation of a Regional Advisory Group is suggested for the coordination of research directions and data collection efforts.

YUZYK, T.R.
1983: Lake Diefenbaker, Saskatchevan: A Case Study of Reservoir Sedimentation.

EXECUTIVE SUMMARY

In 1965 a field survey program vas implemented to monitor general sedimentation patterns, delta formation and bank erosion in what vas to become Lake Diefenbaker. The program consisted of establishing 38 range lines (cross sections), spaced so that they would be representative of changes and surveying them on a regular basis. A sampling program was included to collect information on suspended sediment, bed material and water temperatures. The field programs were conducted jointly by the Sediment Survey Section (Ottava), Water Survey of Canada (Regina) of Environment Canada and the Hydrology Division, Saskatchevan Environment.

After fifteen years of data collection it was agreed that this program should be revieved. The reviev focussed on two principal areas:

1. To compile, analyze and interpret all the data collected from Lake Diefenbaker and document the sedimentation patterns;

2. To evaluate the existing data collection program and identify changes required to ensure an effective and efficient program.

Sedimentation has not significantly affected the reservoir operation, since only 1.4% of the total reservoir capacity has been lost between 1966-1980. The area where sedimentation is significant is in the drawdovn reach, which lost 19% of its volume, or a 1% loss in live storage. Bank erosion and slumping are active and estimated to have accounted for the other 0.5% of the total 1.5% loss in live storage. The dead storage vas computed to have been reduced by 1.3% over this period.

Delta formation was determined to be affected by a lov original bed slope, large vater level drawdown and reduced sediment loadings in the latter years. The bed slopes indicate that the delta structure has yet to reach equilibrium.

Bed material sampling showed that deposited densities were considerably lover than empirically derived values, which greatly affected the deposited load estimates. Based on the sampling findings, a good agreement between station derived loads and the calculated deposited loads was obtained.

The following recommendations are made based on the findings of this report:

1. This joint program should continue, for it is providing a vorthvhile contribution to understanding delta formation and reservoir sedimentation in the prairies. The information is proving to be not only of site specific importance, but transferable to other reservoir studies. It also provides the

opportunity to train and to build upon the expertise already acquired in undertaking sedimentation studies.

2. Due to the lov sedimentation rate, the survey interval should be extended from three years to at least five years, the five year interval will insure continuity between surveys. Since most of the deposition is occurring upstream of the Saskatchevan Landing Bridge, and should likely be the case for quite some time, only those upstream ranges should be resurveyed in the future. Special area studies (Elbow, Swift Current Creek Delta) do not have to be resurveyed as they show negligible sedimentation.

3. Certain data collection methodologies (HYDAC-200 data, cross section vs. area method of surveying) need to be further evaluated and more comprehensive guidelines established for sampling (bed material, suspended sediment) in reservoirs.

4. Since the existing range data were not the most suitable data for evaluating the bank contribution; and since bank erosion and slumping are active, an alternative study using either terrestrial photogrammetry or concentrated cross-sectional work should be considered.

5. Numerical modelling of sediment deposition (such as HEC-6, MOBED) was not in the scope of this report, but it should be considered the next logical step. If undertaken prior to the next survey it may help further streamline the program.

YUZYK, T.R.

1987: Bed Degradation of the South Saskatchewan River below Lake Diefenbaker.

ABSTRACT

The creation of Lake Diefenbaker in Saskatchewan has resulted in significant changes in both the flow and the sediment regime of the South Saskatchewan River below Gardiner Dam. Bed changes are assessed using the cross-sectional and bed material data that were collected from the mid-1960s to 1985.

Degradation appears to be significant only at the ranges (R) nearest the Gardiner Dam. Based on minimum bed elevation, the largest change occurred at R-1-0 where 1.7 m was eroded between 1967 and 1985. Data relating to mean cross-sectional changes indicate the largest change, 0.67 m, for this period was at R-2.7. During the first ten years after closure of the dam changes occurred rapidly. In recent years, however, there has been a stabilization. This has been attributed to bed armouring, as indicated by the increase in median grain size (D_{50}) from 0.24 mm (1968) to 2.50 mm (1985) at R-1.0.

The flow model MOBED was found to overestimate the rate and extent of degradation. For R-1.0 and R-2.7, MOBED overestimated the rate between 1967 and 1985 by two and three times, respectively. The model over estimates because it does not take armouring into account. MOBED should be run again, this time using the newly developed sorting algorithm to see whether the model's predictive capability is improved.

It is also advocated that a much reduced survey, only covering from the dam to R-8.0, should be conducted in 1990; or directly following a release $\geq$1500 m^3/s. There is need to develop better bed material sampling methods to improve on the documentation of the armouring process. The role that large events play is not well understood from the existing data base and therefore this aspect warrants more work. The re-establishment of the Saskatoon station is important to provide further information on the sediment transport regime of the South Saskatchewan River.

YUZYK, T.R.
1987: Proceedings of the Manitoba Sediment Issues Workshop: November 18-19, 1986, Winnipeg, Manitoba.

ABSTRACT

It is becoming increasingly apparent that sediment is an important component in the evaluation of a broad range of environmental issues. In Manitoba, sediment data are used in the assessment of numerous water resources projects such as determining the life expectancy of a reservoir, identifying the effects of a diversion scheme or the designing of irrigation and drainage systems. Water quality studies are starting to focus on the role sediment plays in the sourcing, transfer, and fate of many pollutants. In fisheries, increased sediment concentrations impact negatively on the commercial and recreational fish populations in many areas of the province. Even in agriculture, sediment found in streams translates into lost productive soil from farm lands and into increased maintenance costs to irrigation systems.

The workshop brought together over fifty representatives from consulting firms, universities as well as from federal and provincial governments to identify sediment issues and to comment on the existing network of stations. The information obtained from this workshop is being applied by both the federal and provincial Water Resources Branches as part of an evaluation of the Sediment Program in Manitoba.

YUZYK, T.R.
1986: Bed Material Sampling in Gravel-Bed Streams.

ABSTRACT

The characteristics of gravel beds are examined to provide insight into the complexities involved in sampling fluvial gravels. A review of the different hand sampling methods and bed material samplers is given to show their respective strengths and weaknesses. Criteria established by various organizations and individual researchers for collecting an adequate sample are assessed, the most rigorous criteria being incorporated in the guidelines. A sampling strategy is proposed with the understanding that further research is required.

RÉSUMÉ

Les caractéristiques des lits de gravier sont examinées pour mettre en lumière les aspects complexes de l'échantillonnage des graviers fluviaux. Un examen des diverses méthodes d'échantillonnage manuel et des échantillonneuses de matériaux de fond est présenté dans le but de démontrer leurs forces et faiblesses respectives. Sont évalués les critères établis par différents organismes et chercheurs indépendants pour assurer la collecte d'un échantillon approprié; les critères les plus rigoureux sont adoptés dans les lignes directrices. Une approche visant l'échantillonnage est proposée étant entendu qu'une recherche plus poussée est toujours nécessaire.

YUZYK, T.R.
1984: Reservoir Sedimentation Studies in Canada.

INTRODUCTION

This report was prepared for the following purposes:

- to review knowledge of reservoir sedimentation;
- to present methods to evaluate reservoir sedimentation;
- to compile and document findings from Canadian case studies;
- to make recommendations for further research and studies.

YUZYK, T.R., CHAPIN, N.F.R.
1989: Proceedings of the Alberta Sediment Issues Workshop September 27-28, 1988, Calgary, Alberta.

ABSTRACT

It is apparent from the workshop that the problems relating to sediment are very diverse and in many cases a multidisciplinary approach is required to comprehend the magnitude of the problem. Numerous issues in Alberta relating to streamborne sediments were identified at the workshop. In the agricultural sector, erosion caused by water was found to be a significant problem and considerable research is being done to better understand the mechanics of the problem. At this eroded material enters the waterways, it affects the stream dynamics and channel morphology, which impacts on numerous engineering projects. This sediment may also be transporting contaminants which affect the water quality and the aquatic ecosystem. This consequently has detrimental effects on fisheries.

The workshop also focused on providing information on sediment-related programs delivered by key government agencies, showing how these agencies interact and providing insight into the future direction of these programs. Part of the workshop was spent on highlighting current initiatives of the Sediment Program which is cost-shared between Alberta Environment (River Engineering Branch) and Environment Canada (Water Resources Branch).

RÉSUMÉ

Il est évident, à la suite de l'atelier, que les problèmes reliés aux sédiments sont très diversifiés et, dans de nombreux cas, qu'une approche multi-disciplinaire s'avère nécessaire pour comprendre l'ampleur du problème. Un grand nombre de questions ont été identifiées au cours de l'atelier se rapportant aux sédiments fluviaux en Alberta. Dans le secteur agricole, l'érosion entraînée par l'eau constitue un problème considérable et il se fait beaucoup de recherche pour mieux comprendre les mécanismes de cette situation. Lorsque le matériel érodé s'introduit dans les débouchés, il influe sur la dynamique du cours d'eau et sur la morphologie du canal, ce qui entraîne des répercussions sur beaucoup de projets de génie. Ces sédiments peuvent aussi transporter des substances contaminantes qui ont une incidence sur la qualité de l'eau et l'écosystème aquatique. Les conséquences sont donc fâcheuses sur l'industrie des pêches.

Les participants à l'atelier se sont également attardés à offrir de l'information sur les programmes liés aux sédiments appliqués par des organismes gouvernementaux-clés, démontrant les interactions entre ces organismes et donnant une perspective de l'orientation future de ces programmes. Une partie de l'atelier a été consacrée aux points saillants des initiatives actuelles du programme sur les sédiments dont les coûts sont partagés entre la direction du génie hydraulique d'Environnement Alberta et Environnement Canada (Direction des ressources en eau).

YUZYK, T.R., PENNER, F.

1988: A Review of the Current (1988) Manitoba Sediment Program.

BACKGROUND

In 1986, the Canada-Manitoba Hydrometric Coordinating Committee initiated a major review of the sediment network jointly operated by the provincial and federal Water Resources Branches. This review consisted of three distinct phases.

The first phase involved conducting a workshop to focus on the issues and data needs in the province. A multidisciplinary approach was taken in an attempt to broaden the scope of the existing program and to establish linkages among agencies needed to undertake integrated studies. The workshop was held in November, 1986, with the findings being documented in the workshop proceedings (Yuzyk, 1987).

For the second phase a major data compilation exercise was undertaken. This information was needed to help make sound technical decisions on the operation of the data collection programs at individual stations and to evaluate the network. The report (Penner, Yuzyk and Oshoway, 1987) was compiled and the data presented so that it would be useful to a broad range of users.

The third and final phase involved combining the information obtained from the first two phases and using it to make recommendations on the future and direction of the sediment program in Manitoba. This report completes this final phase.

ZRYMIAK, P.

1987: Linking Sediment Computations to a I-D Mathematical Model.

SUMMARY

In the 1880's under the Public Works Act, Public Works Canada (PWC) assumed responsibility for the maintenance and improvement of the navigation channel in the Lower Fraser River. It has spent millions of dollars on dredging, training structures, and other forms of river maintenance in the lower 25 miles (40 km) to ensure safe operating conditions for vessels entering its ports. In recent times, PWC has requested sediment data from Environment Canada to facilitate the planning of dredging and maintenance operations.

In 1964, Water Survey of Canada (WSC) began supplying sediment data to PWC. WSC used the Cubature method to compute discharge data up to 1968 and then the Power Series method from 1969 to 1972, however, WSC stopped supplying these data when it was concluded that these routing techniques (used to produce water discharge data for sediment load computations) were not sufficently accurate. Since then, WSC's primary objective at the Port Mann pumping station site on the Fraser has been to provide accurate water discharge data.

To achieve this objective, WSC obtained the assistance of the Water Planning and Management Branch (WPM), which had tested and applied a One-Dimensional (1-D) mathematical model to Canadian waterways. WSC asked them to apply the model using 1968 data (as it was the most intensively sampled year for sediment), to provide the discharge data, and to conduct a comparison with the Cubature method (published 1968 data). An account of their work is given by Bernard Morasse (WPM) in his report Generation of the 1968 Hydrometric Data of the Lower Fraser River, Using the 1-D Hydrodynamic Model. Morasse introduces a 1-D model which has been adapted specifically to the Lower Fraser River. He discusses routing methods and compares 1968 mean daily discharges produced by the cubature method to the 1968 discharges from the 1-D model.

This project's objective is to identify a method for producing reliable sediment loadings at the Port Mann site. This report discusses three procedures for computing sediment loads and presents 1968 loadings at Port Mann using these procedures. It compares the relative accuracy of the procedures and identifies the implications of applying the 1-D model.

The report concludes that the mean daily discharges from the 1-D model (using an hourly computation procedure) provides data that on an annual basis are 12% (range 10% to 26%) more accurate than mean daily discharges derived using the Cubature method.

The main recommendation of the report is to implement the hourly computation procedure for producing suspended sediment loadings, using discharges generated by the 1-D Model.

ZRYMIAK, P. and CASHMAN, M.A.
1986: Accuracy and Precision in Sediment Surveys: Annotated Bibliography.

ABSTRACT

This report consists of a compilation of reference material on accuracy and precision relevant to suspended sediment. The reference material pertains to such subjects as sediment erosion processes, sedimentation in reservoirs, lakes and rivers, sediment transport, water quality and water discharge.

RÉSUMÉ

Ce rapport est un compilation de documents de référence concernant l'exactitude et la précision en matière de sédiments. Ces documents de référence traitent d'une variété de sujets dont les processus d'érosion, la sédimentation dans les réservoirs, les lacs et les rivières, le transport des sédiments, la qualité de l'eau et le débit.

ZRYMIAK, P. and TASSONE, B.
1986: Sediment Station Analysis Fraser River at Hansard 08KA004.

SUMMARY

The Water Survey of Canada station, Fraser River at Hansard (08KA004), is located near the headquarters of the Fraser River. Hydrometric data is available from 1954 and sediment data is available from 1972.

Sediment sampling at this site was initiated to obtain data for the FRASER RIVER UPSTREAM STORAGE REVIEW REPORT (Fraser River Joint Advisory Board, 1976). The objective was a plan for flood protection and control in the upper Fraser River Basin. Data from this station were used in the Fraser River Upstream Storage Study's - "RIVER REGIME AND SEDIMENT STUDIES" ((Varzeliotis, 1974) section of the report. This section discusses; possible upstream and downstream morphological effects resulting from dam construction and; sedimentation in the reservoir.

A preliminary study was completed and a report produced in 1974 on the effects of the proposed construction. The report concluded that the effect of river aggradation upstream of the reservoir would be negligible, however, downstream of the dam there would be significant changes. Recommendations stated that because of degradation downstream of the dam and sparcity of sediment data, there was a requirement to continue data collection at this station and at the Marguerite station. Another recommendation was to institute more sediment measuring stations on the Fraser River and its tributaries.

The purpose of this station is to review, interpret and present an analysis of the sediment and discharge data collected at Hansard. It contains station, reach and basin descriptions, a discussion on hydrology of the area, tables and summaries of the data collected, the equipment used and the collection procedures. It also contains an analysis and interpretation which deals with, record length, representativenes, sampling strategy, rating curves, particle size data, suspended sediment yield, sediment sources and dissolved solids.

The results of the analysis indicate:
1) the suspended sediment load transported annually can be quantified by (a) load transported seasonally or (b) water discharge data;
2) the strategy of intensive sediment sampling during high flows was effective for sediment load computations;
3) flows during the 12 years sediment sampling period are represenative of the flows during 31 years of record;
4) flow data are independent, random and homgeneous for period of record;
5) no major changes in delivery of flow or sediment have occurred during their periods of record;
6) the bed load in the system is 2.5% of the total load; and,
7) the life expectancy for the proposed reservoir is 1250 years.

The main recommendation of this report is termination of the intensive sediment sampling program at this station. It also recommends:
1) A miscellaneous program to fill in data gaps;
2) A bed material sampling survey of upstream and downstream reaches; and
3) A clean up of the station file.